SCHOOL SCIENCE AND MATHEMATICS

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A PLACE TO START

The school wrecking program of the United States Chamber of Commerce goes on. Many of its suggested "economies" have been put into operation: the school year has been shortened, subjects have been eliminated, teachers salaries have been reduced. The next step is tuition fees in high schools, and colleges.

The appalling raids of greed and selfishness could not have made such headway had the teaching force been united on a program which all teachers could defend. No external enemy is so dangerous as the enemy within. While it is certainly true that the educational departments of our public schools are very efficiently organized, in comparison with most business enterprises, and the teaching force is more and more becoming a body of professionally trained experts, yet as in every profession there exists a small minority that brings criticism and hardship upon the entire institution.

But the battle has only begun. The forces of public education have lost the first skirmish. In the recent past some improvements were attempted without providing the proper machinery for successful execution of the plans. Disastrous results followed and some reorganization is now necessary. In this reorganization certain obvious faults should be eliminated. Some of these are in the classroom; i.e. right at home. Classes are large, apparatus and books inadequate, extra-curricular and clerical demands heavy, and a host of other excuses for poor work exists; but the public pays and hence has a right to demand an honest return. Moreover, the schools will get better support in combatting the forces of predatory wealth and vicious politics if teachers take

a leading part in correcting faults in all phases of educational procedure. A frequent inventory of personal habits is beneficial. Does our classroom technique economize the time of both teacher and pupils? Have we adopted effective means of keeping pupils alert and thinking on the subject? Do we make definite assignments and properly stimulate home study and reading? Is that study sufficiently directed? Are we making ample provision for drill? Does the study outline contain sufficient problem material for training in independent thinking?

Beyond a few loud-complaining parents and pupils who seem to be anxious only for grades, graduation and less responsibility, there are many who want a real job and a chance to do it well. A little sympathy, encouragement, inspiration, and finally an unrelenting demand for reasonable effort and achievement will insure cooperation from the great majority of both parents and pupils. If we eliminate from our program and routine all that we cannot defend we shall soon have sufficient support to get improvement now utterly beyond reach. America stands for public education supported on the basis of ability to pay. It is up to us to deserve that support and then to keep that ideal constantly in the public mind.

The salary of the president of the Pennsylvania railroad was recently reduced to a mere $60,000 per year, and at his own request in spite of the objections of the board of directors—so it is reported in the press. One point for us to consider is that we help to pay that $60,000 every time we buy a pound of crackers that traveled over the Pennsy.

Ten-thousand-dollar-a-year men are quite common in the utilities. Some of them are college graduates. How many university presidents and school superintendents receive that much? Did you ever hear of a teacher getting that much? Yet these men have spent years in graduate preparation for the greatest business of the Nation.

Are your taxes high? Electricity and gas are necessities. Some company has a monopoly on these commodities in your community. You are forced to buy of that company. A state commission sets the price. Have you thought of that tax?

Is public education expensive? If you think so, try sending your boy or girl to a private school.

Electric power costs on the average six to eight cents per kilowatt-hour. A federal investigating committee has proved that it can be produced and distributed at a profit for less than half that price.

THE SIGNIFICANCE OF SCIENCE TO THE PUPIL IN THE ELEMENTARY SCHOOL*

By Mary Melrose
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In the early days in New England, reading, writing, and arithmetic were regarded as the sole essentials to fit one into the life of the times. But many changes have come about since those bleak days of hardship. Scientific inventions have played an important rôle in these changes, and yet for the most part, our scientific knowledge is not compatible with the progress made in science itself.

The school curriculum, too, has changed. Instead of three subjects there are now fifteen in the Cleveland elementary schools, and, paradoxical as it may seem, elementary science is the newest one to be added.

Let us all think for a few minutes in answer to the question—What are some of the important principles that the leading educators urge that we have in our elementary schools today? I'll just mention four or five items that I am sure all of you would list in answer to this question.

1. Learning is emphasized rather than teaching. Learning situations are to be desired rather than recitations.
2. Child experience.
3. Pupil activity.
4. Pupil participation.
5. In addition to acquiring knowledge and skill in the various subjects, it is hoped the pupil will also have developed certain attitudes and habits.

In applying these criteria to the subject of elementary science, we find:

1. *Learning Situations:* I do not think it an exaggeration to say there is much more opportunity for creating learning situations in elementary science than in other subjects. I personally have seen many, many classroom situations in which the learning process was evident. This is because in science there are so many ways of learning other than by means of words or through reading. There is opportunity for the pupil to watch, handle, observe, experiment, and learn more or verify what he has seen

* Read before the Elementary Science Section of the Central Association of Science and Mathematics Teachers, November 1932.

through reading, group discussions, etc. Of course herein lies the peculiar merit of science, for it gives opportunity for first-hand information, as contrasted with book learning which might be called second-hand information.

It is indeed a difficult matter to convey correct ideas by means of words alone. Not long ago I received a letter from a girl living in a small town in Texas. She asked that a fifth grade pupil answer and tell her about Cleveland. "What kind of crops are raised in your city?" was her only question. Of course it is evident that this child had not the slightest conception of a city.

Sometimes children may also get the wrong conception in science. Perhaps you have heard the story of the boy in a class studying about owls. He announced that an owl had 246 stomachs. Naturally the teacher questioned the accuracy of this statement. But the lad insisted that it said so in the book and soon found the sentence which read—"After examining 246 stomachs of *this* bird, the ornithologist found. . . ."

2. *Child Experience:* Elementary science offers hundreds of opportunities for child experience in each grade. In the first grade, children learn about a canary by having it in the room, listening to it sing, watching it take a bath, watching it eat, helping keep its cage clean, giving it fresh water to drink, noticing its feet and how it stays on the perch.

A third grade teacher brought a young lamb to school, which shows how times have changed since the story of Mary and her little lamb. To my surprise some of the children didn't know what it was. One thought it was a camel, one thought it was a donkey, and another thought it a deer. The children had seen only pictures of these animals.

This shows how much more valuable is an experience with the live animal or real object than with a picture, for pictures are often misleading. Do not let me discourage the use of pictures, however. I merely wish to emphasize that they mean much more in connection with an experience or with the object itself. There is an old Chinese proverb to the effect that one picture is worth 10,000 words. So perhaps we might say, one live animal or one real specimen in the classroom is worth many pictures.

3. *Pupil Activity:* I believe all are agreed that elementary science gives opportunity for children to do many things, such as watering flowers, feeding the pets, cleaning the cages, making bird houses, making electromagnets, compasses, assembling

different class levers such as nut cracker, sugar tongs, scissors, making star maps, etc. We could fill pages with the many things children do in science.

It also furnishes opportunity for many large activities such as in the study of the wind or of shade trees. In the latter study the children make a trip to study the trees in the school yard, a longer trip to learn the varieties in the neighborhood, they make a tree map, collect leaves to study, mount leaves under cellophane, make blue prints, spatter prints, or ink prints of leaves, make tree notebooks, and all the while they are reading and learning about trees.

4. *Pupil Participation:* In science many topics are being studied, because the pupils have brought in the materials on their own initiative. They are also constantly contributing information on some phase of science that they have read about in books, newspapers, or magazines.

In visiting elementary science classes, I am always interested in the many questions children ask about things they want to know. The process of questions by the teacher and answers by the pupil seems to be reversed. And they ask questions irrespective of people or places. At the close of a demonstration lesson on sound before about fifty teachers, I asked the children a number of questions which they answered remarkably well. A boy in the class piped up:—"Miss Melrose, you have been asking us a lot of questions, now I'd like to ask you something." I replied that I hoped I could answer his question as well as they had answered mine.

5. *Habits and Attitudes:* Scientific Method and Scientific Attitude are rather comprehensive terms to use for children from six to twelve years of age. Yet on careful analysis we do find the rudimentary elements of these even in the lower grades. A third grade had a setting hen in the classroom, and the children kept accurate data on every movement of the hen, recording the date and the time of day of each. The hen arrived on April 19, at 3:28 P.M. Such items as these were listed: Turned over eggs; Off of eggs to eat; Sat northeast; Up; On; etc. Well, the eggs didn't hatch, and of course the pupils wanted to know why. The teacher suggested that they look back over the record they had kept of the hen to see if that would tell them. They decided that she was off the eggs too much and so the eggs were not kept warm. In this situation we had three elements of the scientific method; careful observation, accurate recording of

the hen's movements, and the interpretation of the result in relation to the record.

In considering elementary science from another point of view, it is interesting to note its effect on other school subjects.

1. It increases the reading ability of pupils. There is considerable evidence to verify this statement, but suffice it to say that since Doan School has been a curriculum center for science, in the Stanford Achievement Test, the median score for each grade has advanced from 5 months to 2 years beyond the norm for that grade. The librarians from several branches have told me that children are always asking for informational material in science. Unquestionably science furnishes the kind of reading they like. Dr. Washburn of Winnetka, in his latest study of the type of stories children like best, found that almost without exception boys eight years of age or older want true stories or factual material.

So it behooves us not to use the "namby-pamby" material on science that has been written for the young child. Such books give practically no real information and are at times most misleading. These may be all right from the standpoint of the imaginative story, but they are out of place in the teaching of science. Nature has created a much more interesting and fascinating true story than the mind of man can imagine.

2. Science also increases the pupil's language ability. Most elementary principals believe this, for in about a third of our schools, the principal has arranged her departmental program so that language and science are taught by the same teacher. It is indeed quite remarkable to see how the science interest has helped pupils in foreign sections to use the English language.

All content subjects increase both reading and language ability. The child seems to find it easier, however, to express himself in science because he is telling about his own experiences and therefore is not trying to remember the words of the book. The child also talks better with the object in his hand. I am reminded of a story I heard the other day. A girl had given a very good talk on the grasshopper. When she had finished, the teacher said that it was very well done, but that she hadn't followed the outline, and asked what she had followed. The girl replied, "I followed the grasshopper."

3. Science also furnishes a motive for much of the art and handwork. It is so much easier to model a rabbit from clay if one has a live rabbit to work from.

4. It ought to give the pupil a better understanding of certain geography units.

Thus far we have seen how elementary science has affected the general school life of the pupil as well as his work in other school subjects. Let us now consider what is the significance of elementary science to the boys and girls themselves.

1. It keeps alive that spark of curiosity with which most youngsters seem to be endowed. You are all aware of the many questions they ask. Fortunately, this world is as new to them as Mars or Jupiter would be to us. They are anxious to know what things are, and how they work.

2. The science interest motivates and directs much of the pupil's time out of school. Questioning any group of children who are studying science in the right way as to the things they do outside school, and the answers elicited are similar to this list contributed by children of Doan School.

Watch birds
Observe birds' nests
Hunt for insects
Hunt for butterflies and moths
Hunt for cocoons
Look for live things in the brook
Look at the stars and planets
Try to find constellations
Try experiments
Work with electromagnets
Watch ants
Watch animals in the park
Read science books from the library

Due to the existing world conditions, more and more leisure time is being forced upon millions. Likewise, there is less money to spend for pleasure and recreation. So the use of leisure becomes of paramount importance to many a human soul. Had they only the fundamental knowledge, much joy could be had in observing and studying nature at no cost whatsoever.

Last spring some women on a conservation committee were in one of the parks, planning some improvements. They found a group of boys and girls with a bird guide from the ten-cent store, trying to identify a bird. They told these women many things about birds and pointed out several of them.

3. The study of science offers many thrills. What could be more exciting than to see a large cecropia moth come out of its cocoon, or to watch frog eggs develop into tadpoles and tadpoles into frogs, or to see baby chicks come forth from the shell of the egg, or to watch a honey bee comb the pollen from her hair and poke it into her pollen sacks, or to watch a snake shed its skin? A girl who saw a butterfly wing under a compound microscope for the first time wrote of her experience in language that was indeed poetic. Her very innermost being had been touched and awakened.

A lad also gets a thrill out of something he has made, particularly if it "works."

4. Then, too, elementary science enables children who are deprived of the privilege of having animals and pets at home to enjoy them at school. This is especially true in our downtown schools. I have been concerned over the findings by the science teacher at Thomas Edison School, which revealed that these problem boys were not so interested in animals as in other phases of science. My studies involving more than 20,000 pupils show a decided interest in animal life. It would seem that this presents a question for the psychologist to answer—Why are bad boys not interested in animals?

5. There are many things in elementary science that can be understood and learned even by the slowest pupil. On the other hand, there are phases of the subject that offer a challenge to the very brightest pupils.

6. The information the children acquire in science is frequently not known by other members of the family, and this gives him a feeling of self-respect.

7. Science offers the opportunity for developing a hobby, and I believe a hobby is one of the most wholesome possessions one may have.

8. Science may become a dominant interest with some pupils and direct the entire course of their lives.

9. Science seems to make girls and boys more alert and more aware of the things around them. It makes them "keen eyed." I can best illustrate by this picture of Sir Isaac Newton. Here you not only see the sunlight being broken up by the prism into the different colored rays, but you are attracted to the light in Sir Isaac Newton's eye.

Throughout this talk I have repeatedly used such terms as

opportunity for, may happen, etc. Now how can we make these possibilities become realities? There is no magic about the term elementary science, and so it does not follow that if one merely has a class in elementary science all of these desirable things will come to pass. But why did the many illustrations I have cited happen? Because of two fundamental things—the method of teaching and the subject matter. Because we feel the method so important in Cleveland, we require that only a few units be studied each semester. This enables the teacher who is not accustomed to the work to become familiar with the material and the methods of teaching these units. Next year a few more units will be required, and in this way the course of study is constantly evolving.

And so it behooves those of us who are engaged in the practical business of elementary education to be concerned about the development of this newcomer to the curriculum—elementary science. We do not want him to resemble too closely his ancestors—the scientist on the one side or the educational theorist on the other. Yet we want him to possess the good traits of each. We are fortunate in that we have no traditions in this new subject that need to be torn down. We do not want our elementary science rooms to look like miniature high school or college laboratories, nor do we want expensive apparatus.

And we must be careful not to let the scientist dictate what children shall study—but instead let the children's own interest direct the way. This does not mean to follow Johnny's whims today and Mary's tomorrow, for I do not believe such a procedure possible in educating the 75,000 pupils in our Cleveland elementary schools. But by studying the interest of many children, we can find what interests most of them at different grade levels. Our studies include such data on about 20,000 pupils.

We must also try to keep the proper balance between biological and physical science. Girls as well as boys are interested in physical science. In a city, our environment is to a large extent physical.

And so there is much work ahead for all of us to make elementary science live up to all these standards and ideals. But with the interest and enthusiasm evidenced by this group, I am sure the goal will be realized.

Our final hope is that elementary science will help many boys and girls to have fuller, richer, happier lives.

HOW MUCH MATHEMATICS SHOULD WE TEACH?

By Walter G. Gingery
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In a recent article entitled "A New Voyage to Laputa," Quentin Gulliver reminds us that Laputa was, in the original Gulliver's Travels, the land inhabited only by mathematicians. He calls attention also to the statement that, at that time, Laputan was the only universal language, and says:—

"I sought to acquire a knowledge of the rudiments of Laputan or Mathematical Language. Here I encountered formidable and unexpected difficulties. The trouble arose from several causes. First, in countries other than Laputa, the curricula of the schools which in former times had emphasized Laputan as a fundamental subject, had been expanded at the hands of the reformers to include cooking, plumbing, vending, dancing, yodeling, pugilism, quoits, vaudeville, and many other courses. One of the most flourishing divisions was concerned with the teaching of teachers to teach in institutions wholly devoted to teaching other teachers how to teach all of these subjects."

Doubtless, Mr. Gulliver is describing an evolution that has been observed by many of us. As life has increased its complexity, the schools have endeavored to accommodate themselves to the new needs, and have expanded their curricula at the expense of the older subjects,

The following figures, furnished by an exchange teacher, represent the percentages of total time given to the various subjects of the curriculum of a five year London girls' high school. The school receives pupils at age eleven or twelve, so corresponds fairly well to our Junior-Senior High Schools.

Mathematics	18.6%	Geography	6.4%
French	11.8%	Latin	6.2%
English	10.3%	Physical Training	6.2%
Science	8.7%	Art	5.8%
Biology		German	4.8%
General Science		Scripture	4.2%
Chemistry		Music	3.4%
Physics		Domestic Science	3.4%
Botany		Gardening	1.4%
History	6.4%	Writing and Dictation	1.0%

England, of course, is more conservative than we are. They have experimented less and are undertaking less in the way of universal education.

Just now, we are in the control of a group of educators who maintain that citizenship is the chief aim and purpose of democratic education, that citizenship is teachable and that it is the prerogative and obligation of the social sciences to teach it. The older conception seems to have been that citizenship is promoted by those intellectual experiences that exalt truth and righteousness, that emphasize duty and responsibility, that engender brotherly love and beget thoroughness. Such subjects as Latin, Greek, mathematics, grammar, and logic could qualify under the older view-point but, failing to mention specifically the items of vice or virtue connected with modern political life they have been transferred from the core to the periphery of the educational offering.

The modern test for value of a school subject is solely the measure of its usefulness in the life of the individual who studies it. Whether we subscribe to it or not that is the test which is accepted by the current school of pedagogy. Let us, therefore, examine the ability of mathematics to meet the qualifications of practicality. For this purpose, we shall investigate a few functions of the good citizen. We pass by the arithmetic involved in making change, figuring grocery bills, paying the installment man, and checking the speedometer.

Consider the simple activity of reading the front page of the daily news. A typical issue follows: After the weather report involving sunrise and sunset time, temperature Fahrenheit, and barometric pressure; comes the daily circulation for the first ten months of the year. The first column discusses the European debt situation involving various numbers up to $8,000,000,000.00. In the second column *two score* occurs. Then comes a blackmail case with a $2000.00 bond. A bold face type article four or five inches in length deals with the Leonid meteors. In this is involved the theory of gravitation, elliptic orbits, perspective geometry, and relative velocity. This is followed by an article on community fund implying a knowledge of proportion as well as number. Next came a discussion of the Pleasant Run sewer with percents and taxes mentioned. The next article describes the Navy Cruiser "Indianapolis," 10,000 tons displacement and carrying eight-inch guns. The last column on the page describes a Farm Bureau meeting and mentions tax legislation, tax rates, $40,000,000.00 and the tariff. In addition to this is frequent mention of dates, times, and other calendar items.

To read this page intelligently, one must comprehend and be

able to use numbers into billions—be familiar with means of recording time and dates, understand Fahrenheit thermometer readings and barometric readings in inches of mercury; recognize such terms as score, bond, tariff; understand problems in proportion; comprehend percentages, know how taxes are computed, understand our system of weights and measures; be acquainted with Archimedes' Principle of displacement as well as the far more complicated geometrical and mechanical theory involved in the Leonid meteors.

Consider again, the problems involved in doing the family marketing. How does ten cents for a four ounce package of puffed wheat compare with the cost of raw wheat? Potatoes are sold by the peck, bushel or bag, yet each is measured in pounds. How many? We buy milk by the quart with a certain percent of solids and butter fat, yet the farmer sells it by the hundred pounds. Ten cents a quart is how much a hundred pounds? When is it cheaper to buy bread than flour? Six pounds of apples for a quarter is what price per bushel?

Many other similar questions arise not to mention the addition, multiplication, subtraction, and division of rational fractions and whole numbers and the counting of money and making change. As life becomes more complex and more and more items are purchased by the family rather than being produced by them, the amount of such knowledge necessary to intelligent living will increase.

The last generation has added, to what we buy, water and gas by the cubic foot, electricity by the kilowatt hour, and laundry by the piece and pound. It has added the kilocycle and miles-per-gallon. It has introduced installment buying and the forty-two percent loan shark, thus calling for a new interpretation of the old problem of partial payments. Considered from the point of view of practical, prosaic, unromantic necessity, life is becoming more and more quantitative and mathematical each day. And this condition will continue. The next generation will be burdened with numerical, mathematical, and quantitative conceptions now undreamed of.

It is generally conceded that the contribution of the past few decades to world civilization is economic well being, brought about by the industrial revolution, the use of power, and the application of science to industry. I say this without fear of successful contradiction even in this time of economic depression. The meanest shack in our city slums is in all ways superior to

the early Indiana home of Lincoln. The services available in time of crisis for our most poverty stricken inhabitants—city hospital—doctors—public health nurses—dental clinic—are better than the wealthiest family in the state could afford in Lincoln's boyhood. The present means of caring for drought or flood stricken areas or for plague or pestilence is better by a thousand percent than a century ago. Leaving the margin of necessity, we might make the usual comparisons in modes of travel, of communication, of preparing and distributing commodities; with the inevitable conclusion that the recent past has given generously many things that either were utterly unattainable or cost tremendously of time and effort to our forefathers.

It is not necessary to be specific in this direction. I shall, however, attempt to demonstrate two conclusions. First, that these economic advantages were contingent upon the development and a fairly wide dissemination of a considerable amount of mathematics, and second, that their proper use and interpretation require a familiarity with and employment of mathematical materials not required of more primitive peoples. The inevitable conclusion from these two propositions is that ultimately, our educational system must involve more and more, not less, mathematics.

Temporarily, we will assume that Science and its contributions to civilization are dependent upon the antecedence of mathematics. Later, evidence supporting the statement will be presented.

It took more than three thousand years of a rather high type of civilization for man to come to the conclusion that nature is orderly and law abiding in all respect. The ancient Greek and Alexandrian schools of Philosophy recognized certain natural laws, but phenomena not understood were usually relegated to the supernatural. Even Kepler, contemporary of Galileo and immediate predecessor of Newton, Kepler who through twenty-eight years of painstaking research discovered the laws describing the motion of the planets, was a mystic and believed, for instance, that comets were disembodied spirits condemned to spend eternity wandering through outer space.

On a foundation of natural laws, mathematically expressed, laid by Galileo and Kepler, Sir Isaac Newton, perhaps the world's most brilliant generalizing mind, built the law of universal gravitation and the Newtonian Mechanics, inventing the calculus as a necessary tool for its construction. His funda-

mental axiom was that all natural phenomena are orderly, that is, law abiding today, were orderly yesterday, and will be orderly tomorrow, that today's orderliness grew out of yesterday's in an orderly manner and that tomorrow's will grow out of today's in the same manner. Newton was probably the first scholar to really accept that axiom in its entirety. It has taken more than three hundred years and the development of a system of almost universal education for that axiom to gain general acceptance.

In the meantime frontiersmen have cleared and cultivated many new fields in the land of Mathematics or Laputa and practical men have entered these fields and found that they could grow in them harvests of unprecedented usefulness. For example, the field that was first occupied by Clerk-Maxwell, Ohm, Faraday, and Helmholtz blossomed under the tillage of Morse, Bell, and Marconi into modern communication; and under Steinmetz, Edison, and Westinghouse into modern electrification of industry. What mathematics is involved? Imaginary numbers, hyperbolic trigonometry, and the theory of functions of complex variables.

Or again that wilderness that was entered and subdued by Lavosier, Mendeljeff, Avogadro, Gay-Lussac and a host of hardy pioneers and is now cultivated by DuPont, Firestone, Goodyear, and the Ely Lilly Company. The harvests now gathered from this Section of the land of Laputa are blessing, and perhaps damning, mankind in such a multitude of ways that neither time nor intelligence will allow me to catalogue them.

One other example of this sort will have to suffice. That weird, barren and hopeless mountain chain far inland and unpromising whose peaks have been scaled, mapped and explored by Gauss, Bolyai, Lobachevski, and William James Sidis, and which has been named the non-Euclidian Range, and that other lone peak thought to be devoid of every possibility, that peak called the absolute differential calculus scaled first by Riemann not even remotely interested in prospecting for gold or precious stones, have yielded the raw material out of which an Einstein has builded a new order revolutionizing our mechanics and our cosmic theory.

Verily the raw material for the clothing we wear, the medicine we take, the shows we see, the radio programs we hear, the conveyances we ride in, the cosmetics we consume, and the highest intellectual experiences of our lives originate in Laputa.

The mathematical nature of our experiences is becoming more

and more evident. The ability to interpret these experiences depends largely upon our mathematical background. In such a situation there is small probability of any very long continued neglect of the subject in schools where any adequate preparation for life is contemplated. Just what mathematics should be taught in a particular curriculum is a question still open to discussion. Evidently it is as easy to justify some mathematics of a distinctly cultural type as it is to justify English poetry or essays or Caesar or Don Quixote or botany or art or music.

ANCHOR ICE

By John C. Packard
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In response to a letter written to a Norwegian officer, formerly of the Ice Patrol, asking for information concerning the reputed formation of masses of ice at the bottom of large bodies of salt water, instead of at the top, the following interesting note was received.

"You ask me about 'anchor-ice.' We call it 'bottom-ice' or 'sigg-ice.' It sometimes occurs along the southern Norwegian coast. The water is here stratified with the saltier water beneath and the less salty water on top. If the lower layer is colder than the upper layer, it may happen that ice is formed along the boundary between the two layers. On one such occasion the temperature of the lower layer was found to be $-1.4°C$, while the upper layer was $-0.8°C$. The salinity of the water was of such an order that the upper layer could not stand a temperature of $-1.4°C$ without freezing. Ice was therefore formed at the boundary between the two layers and this ice came up to the surface in the form of small circular plates.

True anchor-ice is of a somewhat different nature. It sometimes happens that the water from top to bottom is undercooled. That is: the temperature is so low that it really ought to freeze. If the water is practically motionless however this may not happen for some time. But, in such a case, if a few crystals of ice, in the form of falling snow, let us say, drop into the water or there is a sudden disturbance, due to the water moving over rocks or seaweed, or coming into contact with an anchor at the bottom, the water may freeze all at once at the point of contact and the ice come up to the top in huge quantities. It happened some years ago that some fishermen who were engaged in fishing from small dories outside the Oslo Fiord within the space of ten minutes were surrounded with ice as far as the eye could see. It is difficult to tell why, in some instances, the water can be kept undercooled for a long time without freezing and in some cases not, but the above explanation seems to be the true one."

The measure of a master is his success in bringing all men around to his opinion twenty years later.—Emerson.

To really understand a man we must judge him in misfortune.—Napoleon.

PRACTICAL EXPERIMENTS IN RADIO WITH THE LABORATORY VACUUM TUBE UNIT

By Sol D. Prensky

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There are many teachers of Physics and General Science who appreciate the value of satisfying the students' interest in radio and who would like to offer some basic radio experiments in their course. However, it is often extremely difficult for them to accomplish this purpose—even where time for it can be found by skillful maneuvering—because of the lack of radio apparatus suitable for student experimentation. Some of us have resorted to the alternative of reclaiming junk radio parts by fishing through discarded sets, and have ended up with a crazy-quilt assortment of parts, which, by heroic measures, were actually used by students to build a workable one-tube receiving set. In spite of the obvious uncertainty of the materials used, this kind of salvaging work proved to be very exciting for our radio club, but was entirely unsuitable for class work, since most of the time was consumed in mechanical activities like getting the parts and heating up the soldering irons, leaving little time for any real experimentation.

The apparatus which we describe here, known as the Laboratory Vacuum Tube Unit, was developed by the writer as the result of many experiences such as mentioned above with radio clubs and classes. It is designed in compact and inexpensive form to cover a series of practical experiments to be done by the students. Each component part of the unit such as the tube socket or the general purpose transformer, is brought out to its own binding posts. In this way the circuit can be changed at will by hooking up the external connections to these binding posts in order to perform any one of the series of experiments. As is shown in the illustrations, provision is made for the student to follow the circuit diagram from post to post while making these connections so that he becomes familiar with the circuit. This leaves ample time for the actual doing of the experiment from instruction sheets which are supplied with the unit. By using a special transformer with suitable variable ratios, the unit is made flexible enough to cover many uses.

The experiments, by number, which can be performed with this unit are as follows:

1. To generate an audible note (by audio frequency oscillation of the tube)
   (a) To show the amplifying properties of a vacuum tube
   (b) For code signalling work
2. To construct a one-stage amplifier for general purposes, such as a photo-cell amplifier
3. To operate a microphone amplifier (as shown in photo, Fig. A) (This also can be used to give a practical demonstration of loud-speaking telephony over room distances.)
4. To determine vacuum tube characteristics
   (a) Plotting the curve of a tube as a simple rectifier
   (b) Plotting the $E_p - I_p$ curve (see illustration)
   (c) Plotting the $E_g - I_p$ curve (see illustration)
5. Inductance and capacity effects
   (a) To show opposite kind of effects on interruptions of direct current
   (b) Effects with alternating current
   (c) Effects on the pitch of an audible oscillation

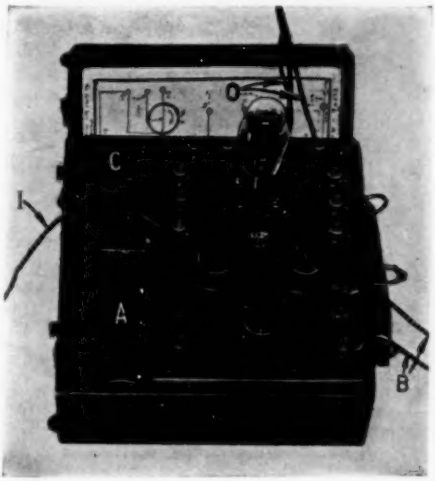

FIG. A. LABORATORY VACUUM TUBE UNIT set up for one of the series of experiments which can be performed with it: EXP. NO. 3 MICROPHONE AMPLIFIER. External connections between binding posts are made by the student in a few minutes from the circuit diagram. (For explanation of symbols, see Fig. B)

Additional experiments that can be performed in conjunction with the Radio Frequency Unit are as follows:

6. Radio receiver
   (a) Broadcast wave
   (b) Short wave (by use of switch and plug-in coils)
   (c) Adding one-stage amplifier to regenerative detector (as shown in photo)
7. Radio Frequency Oscillator
   (a) Unmodulated

(b) A. C. modulated
(c) Beat-frequency meter

8. Wireless transmitter
(Carrier wave modulated by microphone to transmit speech through the air.) (As shown in photo.)

This list, covering a broad field, is given as one from which the instructor would pick those experiments best suited to his needs.

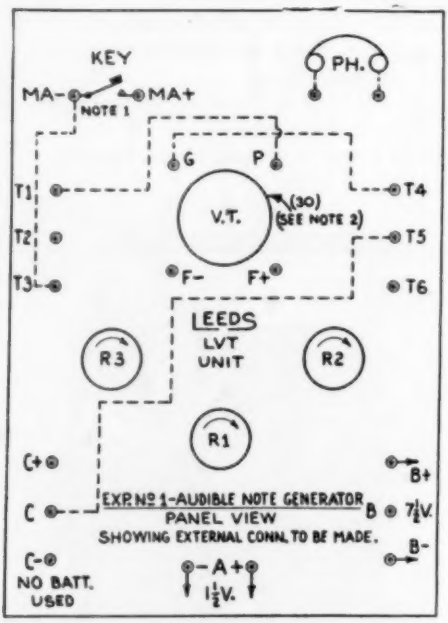

FIG. 1

It will be noted from these experiments and from the illustrations accompanying them that audible means are stressed through the sound in the ear-phones or loud-speaker, in addition to the meter readings where indicated. This is in line with the students' previous contact with radio and satisfies his fundamental curiosity about radio, namely—how sounds are produced and carried through the air without wires. This method also avoids the use of high power which is necessary for producing visible effects. For this same reason of appealing to the students' natural interest, the first experiment deals with the production of the dots and dashes of the International Code, which to the students' mind, signifies radio. Many students wish to go further with the study of the code, and in such

cases the tube unit will serve as a model for the code practice set that they can easily build.

Referring now to Fig. 1, the symbols for the component parts are shown marked on the panel. After inspecting the circuit diagram, Fig. 2, the student proceeds to hook up the binding posts on the panel according to the dotted lines on the instruction sheet furnished with the unit for that experiment. This leaves the major part of the period for him to do the actual experimenting.

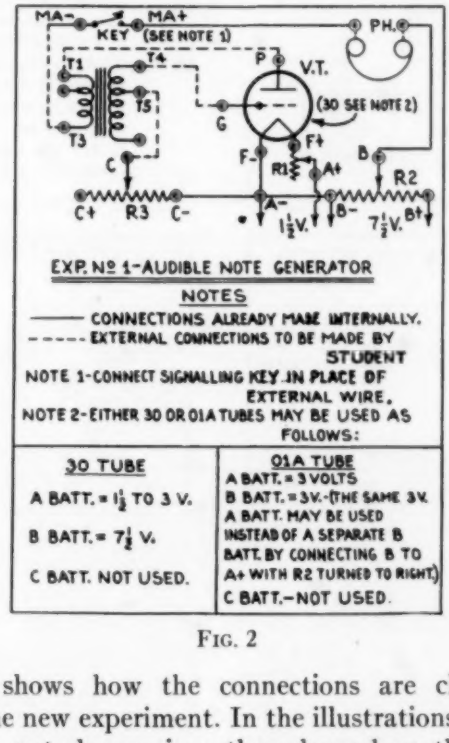

FIG. 2

Figure 3 shows how the connections are changed very simply for the new experiment. In the illustrations, the sources of power are not shown since they depend on the individual laboratory facilities. The dry cells called for are usually available in a science laboratory and the current drain from these is very slight, (always less than 0.1 ampere). The 30 tube works well at $1\frac{1}{2}$ v., (although rated at 2 volts), and in this way is foolproof against excessive turning up of the rheostat. For the B supply, the 110 volt D.C. line can be used if filtered, or a B supply working from the 110 A.C. line is advisable, in preference to B batteries. There are numerous B eliminators on the market which supply more than ample power for our purpose, and the voltage may be anywhere from ninety volts up even where a

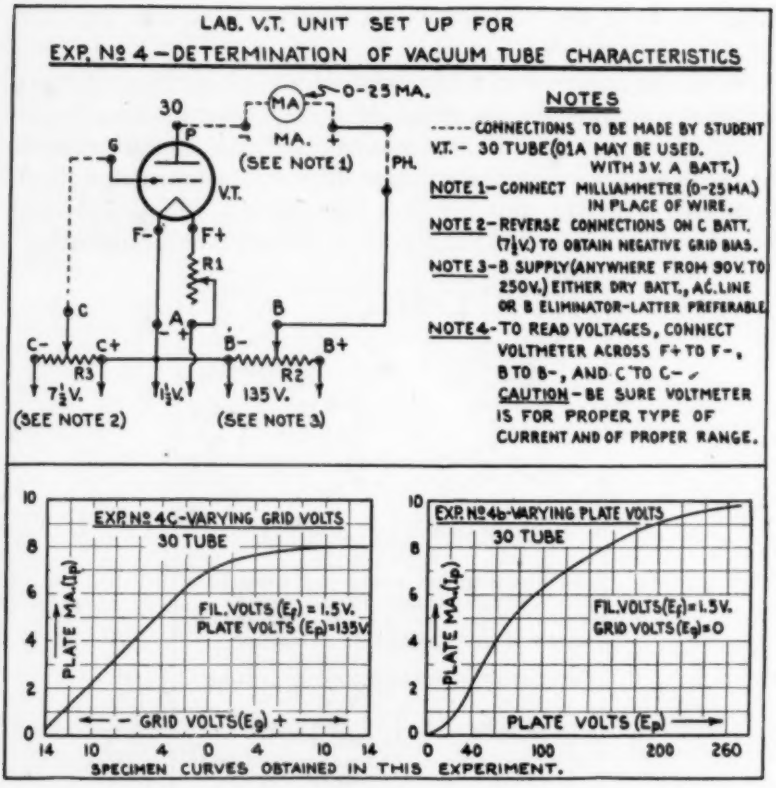
LAB. V.T. UNIT SET UP FOR
EXP. Nº 4 — DETERMINATION OF VACUUM TUBE CHARACTERISTICS
0-25 MA.
MA.
(SEE NOTE 1)
30
G
P
PH.
V.T.
F-
F+
R1
C
A
B
C-
C+
B-
B+
R3
R2
7½ V.
1½ V.
135 V.
(SEE NOTE 2)
(SEE NOTE 3)
NOTES
----- CONNECTIONS TO BE MADE BY STUDENT
V.T. - 30 TUBE (01A MAY BE USED. WITH 3 V. A BATT.)
NOTE 1 - CONNECT MILLIAMMETER (0-25 MA.) IN PLACE OF WIRE.
NOTE 2 - REVERSE CONNECTIONS ON C BATT. (7½ V.) TO OBTAIN NEGATIVE GRID BIAS.
NOTE 3 - B SUPPLY (ANYWHERE FROM 90 V. TO 250 V.) EITHER DRY BATT., A.C. LINE OR B ELIMINATOR - LATTER PREFERABLE.
NOTE 4 - TO READ VOLTAGES, CONNECT VOLTMETER ACROSS F+ TO F-, B TO B-, AND C TO C-
CAUTION - BE SURE VOLTMETER IS FOR PROPER TYPE OF CURRENT AND OF PROPER RANGE.
EXP. Nº 4C - VARYING GRID VOLTS
30 TUBE
PLATE MA. (Ip)
FIL. VOLTS (Ef) = 1.5 V.
PLATE VOLTS (Ep) = 135 V
- GRID VOLTS (Eg) +
14 10 4 0 4 10 14
EXP. Nº 4b - VARYING PLATE VOLTS
30 TUBE
PLATE MA. (Ip)
FIL. VOLTS (Ef) = 1.5 V.
GRID VOLTS (Eg) = 0
PLATE VOLTS (Ep)
0 40 100 200 260
SPECIMEN CURVES OBTAINED IN THIS EXPERIMENT.

FIG. 3

higher voltage is specified on the diagram. It will be noted that voltages may be measured conveniently by plugging the voltmeter leads into the special binding posts provided, without disturbing the connections already made.

Figure B shows the use of the tube unit with another unit called the R F unit. The latter is designed in the same way, having each component part brought out to its own binding posts, making it a very flexible unit for work as a detector or R F amplifier. The combination shown here will be found to be a very useful model for boys wishing to building their own short wave sets and gives very efficient performance. Short wave reception is provided, in addition to the broadcast stations, for amateur phone, aviation, police reports, etc. A set of plug-in coils and a long-wave to short-wave switch take care of all these bands. Also a chart is furnished showing the fre-

quencies for the various dial settings, making the R F unit useful also as a frequency meter.

When used as a wireless transmitter, the R F unit will send out waves having the frequency shown by the dial setting when the unit was used as a receiver. By choosing the proper frequency, its operation as an oscillator will cause no more interference with outside stations than that caused by any regenerative receiver in the process of listening-in. In fact, we are here making use of this very point, namely—that a regenerative receiver will act as a transmitter when the tube goes into oscillation. For this reason, when operated according to the instructions given, no concern need be felt about the interference caused in this experiment as its use is in the same class as the widely used service oscillator. Still, in spite of its extremely low power, excellent results are obtained in transmitting signals or voice through the air, to be heard on a receiver in another room. If an electric set is used for receiving, high amplification will result.

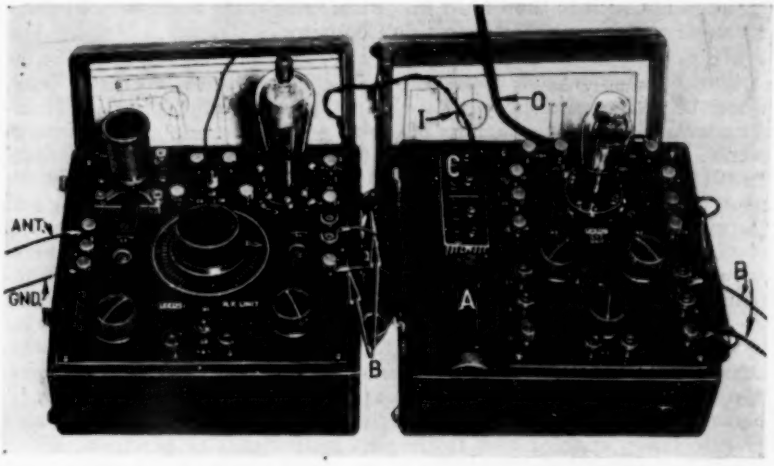

FIG. B. THE LABORATORY VACUUM TUBE UNIT being used with THE RADIO FREQUENCY UNIT for EXP. NO. 6 C SHORT WAVE RECEIVER (with amplification). NOTE: This same combination, with slight external changes, is also used in EXP. NO. 8, MINATURE RADIOPHONE for wireless transmission of speech from room to room.

SYMBOLS: A = A Battery B = to B Supply (See text)
C = C (or microphone) Batt. O = Output to Phones or Loud Speaker.
I = Input wires coming from source to be amplified (Such as microphone in Fig. A or radio detector in Fig. B)

The use of apparatus in units such as these, then, will supply the science teachers with an outfit which is readily adaptable to many laboratory uses. Supplied as they are each with its box and cover (by the Leeds Radio Co.)[1] the units are self-contained and convenient for storage and also reasonably fool-proof against the whims of the students. This apparatus offers a logical means of bringing home to the student a long-denied practical application of the knowledge gained from the principles of science—the field of radio!

[1] 45 Vesey St., N.Y.C.

HERMAN PAUL SACHSE

Herman Paul Sachse, who had devoted his life to the design and production of scientific instruments, and who was associated with a number of prominent firms, both in America and Germany, in the course of his career, died August 12, 1933, at the age of 53, in the Passavant Memorial Hospital in Chicago, Illinois. At his death, he held the position of Factory Manager with the Central Scientific Company in Chicago.

Mr. Sachse, who was born in Germany, first entered the scientific instrument industry as an apprentice in the Zeiss Optical Works in Jena, where he became proficient, not only in the construction of scientific instruments, but in the principles of design and the testing of these instruments. He later became associated with Toepfer and Sohn in Pottsdam. In 1911, he came to America to accept a position of Superintendent in the plant of Eugene Dietzgen Company in Chicago. His skill in the testing and inspection of optical instruments later opened an opportunity to enter the employ of Bausch Lomb Optical Company in Rochester, N. Y., as General Inspector. In 1918, his talents were secured by the Central Scientific Company in the production of optical devices for the control of gun fire in the great war. At the close of the war, he assumed full charge of the production of scientific instruments and laboratory apparatus in the factory of this company, first as Factory Superintendent, and later as Factory Manager. Mr. Sachse's unusual ability as an apparatus and instrument designer, his intimate knowledge of manufacturing processes, and his well-developed artistic sense, enabled him to develop instruments of precision, which could be produced economically in the small quantities in which such products are made, but still of the perfect proportions and pleasing appearance that really fine instruments justify.

With the death of his wife in 1930, Mr. Sachse found greater solace in his work, to which he applied himself with the utmost vigor. He found ample opportunity for his efforts in the latter months of his life in the development of manufacturing designs and the production of numerous exhibits for the basic sciences in the Hall of Science of the Century of Progress Exposition in Chicago. Unfortunately, he was denied the pleasure of seeing the exhibits, which he had a part in creating, although he could see the buildings of the World's Fair from his hospital window. Mr. Sachse is survived by two daughters, Marguerite and Virginia, and a son, George, who will reside with their maternal grandmother.

THE PLACE OF EARTH SCIENCE IN THE TRAINING OF A TEACHER

By Robert H. Mitchell
Muskingum College, New Concord, Ohio

"Man spends his lifetime on the earth. He and the earth are inseparable." (1) Man is truly inseparable from the earth, for he has never succeeded in leaving this planet. He is dependent upon the earth for his food, clothing and shelter. Being so dependent upon the earth for his very life it is essential that he know something about the earth if he is to compete successfully with his fellows. That "knowledge is power" is certainly true with respect to man's knowledge of the earth, for he who knows well the earth and its ways can live best and use his knowledge as a source of power.

Earth science may be defined as the study of the earth, the processes affecting the earth, and the relation of man and his activities to the earth. That phase of earth science which deals with the earth and the processes affecting the earth is commonly called Geology. That phase which deals with man and his activities relative to the earth is Geography.

These two phases of earth science are closely related. Geologic activity produces part of the geographic environment in which man lives. Some of the important geographic factors of environment are surface features, climate and soil. In so far as certain processes are continually at work to change the present surface of the earth and these same processes have been at work during the past to produce the present surface features they are the result of geologic activity. Thus we see that the geographic factor of surface features is a direct result of geologic activity. Plains, plateaus and mountains, the major land forms, have an important effect upon the people who live on them and therefore are geographic. These land forms are the result of certain geologic processes working upon the underlying rocks. These considerations are geologic. In order to better understand the surface features of the earth, which so definitely effect man's activities, a knowledge of geology is necessary to supplement geography.

A short time ago a certain high school geography teacher asked me to discuss glaciation with her students. They had been studying the geographic effect of glaciers and had many questions which she could not answer It must be said in her favor

that she is an excellent geography teacher and holds an M.A. degree but her knowledge of geology was too limited to answer the questions asked on this subject. She had the students write out their questions and hand them to her, these were turned over to me as a guide for our discussion. Most of the questions showed great interest on the part of the students. I shall list a few of them here to illustrate the type of question a geography teacher may meet in studying glaciers. "How do you account for the driftless area in North America?" "How do we know that a glacier covered part of North America at one time?" "Does vegetation grow on glaciers, if so how?" "How do glaciers cause waterfalls and lakes?" As I read over these and many other questions concerning glaciers I could not but wonder how the teacher of geography who was not as well prepared for her work as the one mentioned and who did not have a geologist at hand upon whom she might call for help would have handled this situation.

Climate, which may be defined as the temporary condition of the atmosphere, is an important factor of geographic environment. The atmosphere is the gaseous unit of the earth. In so far as geology is the study of the earth a study of the temporary condition of the atmosphere is a geologic consideration.

"The character of the soil to a large extent controls the economy of the people who inhabit a certain area. Moreover, the character of the soil is the basis for the interpretation of many intimate individualities in the social character of the people." (2) If this is true the soil is one of the important forms of human environment. If we examine a handful of soil we will find it composed of broken fragments of rock material usually with more or less organic matter in various stages of decomposition. Weathering, to the geologist, is any process by which rock is broken up or decomposed. In other words it is soil formation. The formation of soil involves certain geologic considerations. Our examination of the handful of soil may show not one type of broken rock, but many. These rocks have been broken up and decomposed by several geologic processes both chemical and mechanical. Soil, once formed, may be transported by geologic agencies; such transportation is know as soil erosion. Soil erosion may take place under favorable conditions and thus the soil is carried away from a region, thereby decreasing its value for agriculture. Thus we see that soil formation and soil erosion call for geologic considerations. Because geology and geography

are so closely related it seems to me that an understanding of at least the fundamental geologic processes is essential to the proper appreciation of geography.

Having defined earth science and noted the interrelation of its two chief branches, let us turn our attention to a discussion of the value of earth science outside the field of geography. The statement, "He (man) and the earth are inseparable" is equally true of plants and animals for they too spend their lifetime on the earth and are inseparable from it. How often is the study of the earth neglected in nature study courses in grade schools? The dictionary defines nature, which comes from the Latin word "natura" meaning born, as "that which is the source or essence of life. The power which produces existing phenomena whether in the total or in detail: The world of matter or of matter and mind." Certainly plants are born of the earth. The plant in turn furnishes the necessities of animal life and both plants and animals furnish the necessities of human life. As we look at nature about us we see the things most familiar to us, plants and animals. Have you ever stopped to consider that these organisms exist only at or very near the surface of the earth? Beneath these organisms extending downward to unknown depths are great masses of rocks all composed of minerals.

We have already mentioned the relation of geology to the formation of soil. If it were not for the rocks from which the soil was derived by a geologic process called weathering we could not have soil, consequently no plants and no food for the animals. In other words, were it not for the earth with its rocks and the processes working on the rocks, we could have no organic nature to study. When we consider these facts we can readily see that a study of the earth with its rocks, minerals and processes are a necessary part of any nature study course. The biologic side of nature study so often stressed could not exist without the rocks and minerals and the processes which work on them, because rocks are made up of minerals and the rocks upon decomposition form soil which makes possible organic life.

The formation and destruction of soil, both geologic processes, as well as the conservation of soil are problems vitally important to the agriculturalist. In order to build up his soil physically and prevent its destruction by erosion the farmer should know how these geologic processes act. He should know how floods are caused and how they can be prevented. Information

concerning the ability of certain soils to hold water, the type of soil, the relation of topography to the possibility of early frosts etc. helps him to adapt his crops to the physical conditions so that he may get the greatest possible return for his labor.

History and earth science are closely related. "From the earliest times down to the present minerals have played an exceedingly important part in the development and progress of the human race." (3) The period in which a mineral, flint, and certain of the rocks were used for implements is called the Stone Age. Later man found that he could use certain metals to his advantage and still later he found a black stone, coal, which would burn. Today our whole civilization is built upon metals which are derived from minerals.

"History can no more be studied apart from the physical scene in which the events recorded took place than can an economic or social condition existing at any period of history be properly studied without taking into account physical conditions. History is concerned with the causes of the trend of events and in so far as these causes are physical they are geographic. The roots of history run deep into the ground." (4)

Slavery in the United States shows the relation of earth science and history to a good advantage. In the early days of colonial history, slavery was established all along the Atlantic coast. Everyone felt the need of slaves to do their work. The New England region has long cold winters during which the slave had to be clothed, fed and sheltered and during which he produced no wealth for his owner. Since it soon became apparent that the slave did not produce enough to pay for his keep during the winter season, slavery in the North died a natural death. In the South the climate allowed the use of slaves to a good advantage. Because of the climate the North could not use slaves to advantage while the South could. Thus we see that climate, a geographic factor, favored slavery in the Southern states but not in the North. "If the growing season in the Southern states had been no longer than it is in New Jersey there would have been no slavery question in American history after the establishment of the United States." (5)

History gives us accounts of the invasions of such peoples as the Huns, Tartars, Mongols, Turks, etc. The causes of these invasions can often be found in the geographic environment of the invader. These people are nomads who, in many cases be-

cause of lack of moisture which meant lack of food for themselves and their flocks, rode into the more favored farming regions in search of food. The Chinese Wall, finished about 200 B.C., was a means taken to prevent such invasions in China. In the 4th and 5th centuries the Huns invaded Europe from the north as far as the Rhine. History is full of invasions and movements of peoples which can be explained wholly or in part on a geographic basis. The recent Chinese-Japanese trouble is the result of geographic factors working in the overpopulated, mountainous Japan. History is interested in the activity of peoples and the date of such activity while geography is interested in the cause of the activity and the place where it occurred.

Isolation, due to such physical barriers as mountains, is shown by a study of the mountaineers in Kentucky, Virginia, West Virginia, Tennessee and the Carolinas. These people have made little progress for about 150 years. Ancient customs have been preserved which have long since been forgotten by the outside world and many of the people speak a language which is more or less Shakespearean.

Mountains form excellent political boundaries. Peattie says, "There is no other physical feature, except the strand line of the sea, which is so frequently employed to indicate political delimitation." (6) Mountains tend to keep the people living in neighboring valleys apart and each group develops its own habits, customs and even language or dialect. The difference between ancient Athens and Sparta was a result of the isolation of their valleys. Also the old Greek city states were for the most part a result of difficult communication due to the mountainous country. Because of isolation we find numerous small independent states such as those in the mountainous region of southern Europe.

Mountains are the result of certain geologic processes working from within as well as upon the surface of the earth. In order to understand the condition of mountain peoples we must understand the geographic effect of mountains upon the people.

Sociology is, especially in the earlier development of the race, a product of earth science. Dr. Ross says, "It is obvious that the characteristics of the immediate physical environment—climate, soil, minerals, topography, elevation, contour, waterways, rainfall, harbours, etc.—dictate the size and local distribution of a population, the key industries, the basic occupations, the lines of specialization, the mode of life, the routes of

migration, the channels of transportation and the character of commerce. In a word, the environment determines the general economic basis of society." (7)

Climate has a very great influence on social conditions. The jungle man whose food is provided by nature the year round and who needs little or no shelter or clothing has no need to exert his energies. It is not surprising that under such conditions of climate the jungle man has made very little social progress. Frequently the man in the tropical jungle lacks the energy to provide himself with government hence is ruled by people in the temperate zone. Thus we see that climate has had an effect upon his government. Contrasted with him is the man of the polar regions who must continually struggle against adverse climatic conditions. His culture and social life have not progressed beyond the primitive stage.

Dr. Ross says, "Sex relations bear witness at times to the power of environment." People living in infertile mountains and plateaus because of the fear of overpopulation have established such customs as late marriages or segregation into monasteries, as for example in Tibet. Polyandry is often the result of restricted and infertile farm land. It is sometimes practiced among mountain people to avoid dividing the farm land which can scarcely support a family. Polyandry is also practiced on small islands where land is scarce.

In the course of social development marriage begins to take the form of monogamy. "Thus as civilization develops, social institutions are moulded more by the products of human thought and less by impressions of nature. . . . Man becomes a citizen of the world rather than a parish and psychology rather than geography provides the keys to social evolution." (8)

We see that in the earlier development of society that the various physical factors of earth science have played an important part, hence a knowledge of these factors is valuable in understanding their results on society.

Seligman bears out some of our previous statements when he says, "Man, like all animals, is indissolubly bound to the soil. He is in last resort dependent upon nature for what he is and what he has accomplished." He further states, "This is especially true of his economic life, which as we have seen, consists ultimately of his relation to material things. The basis of economic activity is the material environment. The modern sciences of geology, of meteorology and of commercial and anthropo-

geography have enabled us to comprehend phenomena whose significance was until recently but vaguely apprehended. The economic aspects of the material environment may be summed up under the four heads of the climate, the geological structure, the flora and fauna and the geographical location." (9)

Some religious ideas are wholly or in part the result of geographic conditions. Because the overflow of the Nile river is a matter of life or death to the Egyptians, the adoration of the Nile is a part of their religion. On the high plateaus of the Andes it is always cold hence sun worship is quite natural. The chief god of India was Indra, the rain giver and Typhon, the Satan of Egypt, was the god who sent the parching winds.

J. Russell Smith says, "Hell is hot. Did you ever wonder why? But not all Hells are hot. Among the pre-Christian Scandinavians Hell was encased in snow and eternal ice." (10) He goes on to show that to the Norseman who lived in a cold region that a hot Hell was too pleasant. He states further, "Hell is the theologian's attempt to portray in figurative language unpleasant things for the future. Figures of speech to be effective must come close home and speak of things that are well known." To the Norseman Heaven was a place of heat and Hell a place of eternal cold. To the Hebrew who lived on the edge of the desert Hell was a place of heat. Since one of the worst imaginable things that could happen to them was to be lost on the desert and suffer from heat and thirst a hot Hell was effective to these people and decidedly ineffective to the Norseman. In the same way the Hebrew was beset on every hand by enemies so that walls were built around the cities for protection, hence Heaven to them was a walled city. To Mohammed, living in the Arabian desert, Heaven was a place of cool shade and plenty of water. Dr. Ross suggests, "Whether a people conceive of Heaven as a place of eternal rest or a garden . . . will naturally depend on what that particular people regards as the acme of happiness; and this in turn will depend upon the special kind of discomfort, privation, unhappiness, want and suffering to which a people is subjected—in short the adverse elements of its environment." In so far as these adverse elements are physical their consideration properly belongs to earth science.

We have tried to show how earth science gives us a background to the understanding of nature study, history, customs agriculture, sociology, economics and religion—all subjects in which a teacher may be asked to give instruction. The old say-

ing if you know a thing you can teach it is no longer true, if it ever was true. In addition to the knowledge of the content material and a thorough training in teaching methods a good teacher must have a sufficient background in these subjects to be able to lead the students to a clear understanding of the subject matter. Children are naturally inquisitive. The children who are interested in a subject naturally have questions about the material. One way in which a teacher can keep the children interested is by encouraging them in asking questions and by giving them the correct answers or help them find them. Such answers as, "That is not in the lesson," "Look it up for yourself," "I do not know; that is not on the subject," if used too often are apt to kill interest. How can a teacher answer questions intelligently if she does not have a background greater than that of the child?

One course of study which gives at least a partial background to a large number of school studies is earth science. Some teacher training institutions require geography as a definite part of the teacher training program but we contend that geography alone is not sufficient. In order to properly understand geography a knowledge of geology is essential as we have already noted in the relationship between geology and geography. Does it not follow that a course on earth science would prove valuable in the training of a teacher?

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Remember what Simonides said—that he never repented that he had held his tongue, but often that he had spoken.—*Plutarch.*

GEOMETRIC PROOFS OF CERTAIN TRIGONOMETRIC RELATIONS

By Benjamin Braverman
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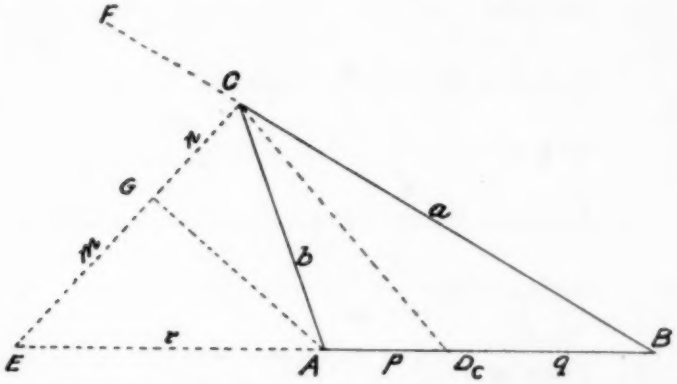
THEOREM I—THE LAW OF TANGENTS

In any triangle the sum of two sides is to their difference as the tangent of one-half the sum of the opposite angles is to the tangent of one-half the difference of these angles.



Given: $\triangle ABC$ with $a > b$

To Prove: $\dfrac{a+b}{a-b} = \dfrac{\tan \frac{1}{2}(A+B)}{\tan \frac{1}{2}(A+B)}$

Proof: 1. Let CD be the bisector of $\sphericalangle ACB$
and CE be the bisector of $\sphericalangle FCA$
Represent the segments AD, DB, AE by p, q, r respectively

2. Then $\sphericalangle ECA = \frac{1}{2}(A+B)$
and $\sphericalangle CEA = \frac{1}{2}(A-B)$

3. Now $\dfrac{a}{b} = \dfrac{q}{p}$

Hence $\dfrac{a+b}{b} = \dfrac{q+p}{p} = \dfrac{c}{p}$

4. Also $\dfrac{a}{b} = \dfrac{EB}{AE} = \dfrac{c+r}{r}$

Therefore $\frac{a-b}{b}=\frac{c}{r}$

5. Hence $\frac{a+b}{a-b}=\frac{r}{p}$

6. From A construct $AG \perp EC$
   Call the segments EG and GC m and n respectively
7. Since $CD \perp EC$
   $AG \parallel CD$

8. Therefore $\frac{r}{p}=\frac{m}{n}$

9. Now since $\measuredangle ECA=\frac{1}{2}(A+B)$ and $AG \perp EC$

   $\tan \frac{1}{2}(A+B)=\frac{AG}{n}$

10. Also since $\measuredangle AEC=\frac{1}{2}(A-B)$ and $AG \perp EC$

    $\tan \frac{1}{2}(A-B)=\frac{AG}{m}$

11. Therefore $\frac{\tan \frac{1}{2}(A+B)}{\tan \frac{1}{2}(A-B)}=\frac{m}{n}$

12. But since $\frac{m}{n}=\frac{r}{p}$

    $\frac{a+b}{a-b}=\frac{\tan \frac{1}{2}(A+B)}{\tan \frac{1}{2}(A-B)}$

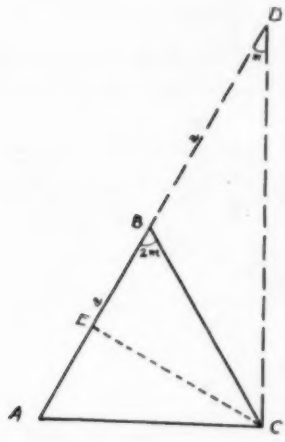
THEOREM 2

The sine of twice an angle is equal to the product of twice the sine of the angle by the cosine of the angle.

Given: Isosceles $\triangle ABC$, with $AB=BC$
AB is prolonged its own length to D and DC is drawn
CE is an altitude on AB
$\measuredangle ADC$ is represented by m, and $\measuredangle ABC$ which is twice $\measuredangle ADC$ is represented by $2m$

To Prove: $\sin 2m = 2 \sin m \cos m$

Proof: 1. Since CE is $\perp$ to AB, $\sin 2m=\frac{CE}{a}$



and $\sin m = \dfrac{CE}{DC}$

2. Hence $CE = DC \sin m$

3. Since $DC \perp AC$, $\cos m = \dfrac{DC}{2a}$

4. Hence $DC = 2a \cos m$

5. Therefore $\sin 2m = \dfrac{\sin m \; 2a \cos m}{a} = 2 \sin m \cos m$

THEOREM 3

The cosine of twice an angle is equal to twice the square of the cosine of the angle minus unity.

Given: The same figure as was used in Theorem 2

To Prove: $\cos 2m = 2\cos^2 m - 1$

Proof: 1. $\cos 2m = \dfrac{EB}{a}$

2. Also $\cos m = \dfrac{EB + a}{CD}$

3. Therefore $EB = CD\cos m - a$

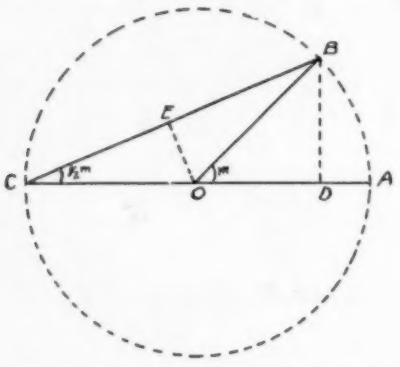
4. $CD = 2a\cos m$

5. Therefore $EB = 2a\cos^2 m - a = a(2\cos^2 m - 1)$

6. Therefore $\cos 2m = \dfrac{a(2 \cos^2 m - 1)}{a} = 2 \cos^2 m - 1$

THEOREM 4

The sine of half an angle is equal to the square root of one-half the difference between unity and the cosine of the angle.



Given: The unit circle whose center is O, and angles BOA and BCA
$\sphericalangle BOA$ is represented by m and $\sphericalangle BCA$ which is one-half of $\sphericalangle BOA$ is represented by $\frac{1}{2}m$

To prove: $\sin \frac{1}{2}m = \sqrt{\dfrac{1-\cos m}{2}}$

Proof: 1. Let BD be $\perp AC$ and OE be $\perp$ to BC

2. Then $BD = \sin m$
$OD = \cos m$
$CD = 1+\cos m$

3. Also $BC = \sqrt{(BD)^2+(CD)^2}$
$= \sqrt{\sin^2 m+1+2\cos m+\cos^2 m}$
$= \sqrt{2+2\cos m}$

4. Since OE bisects BC, $CE = \dfrac{\sqrt{2+2\cos m}}{2}$
$= \sqrt{\dfrac{1+\cos m}{2}}$

5. Now $OE = \sqrt{(OC)^2-(CE)^2} = \sqrt{1-\dfrac{1+\cos m}{2}}$
$= \sqrt{\dfrac{1-\cos m}{2}}$

6. But $OE = \sin \frac{1}{2}m$

Hence $\sin \frac{1}{2}m = \sqrt{\frac{1-\cos m}{2}}$

THEOREM 5

The cosine of half an angle is equal to the square root of half the sum of unity and the cosine of the angle.

Given: The same figure as was used in Theorem 4

To Prove: $\cos \frac{1}{2}m = \sqrt{\frac{1+\cos m}{2}}$

Proof: 1. $\cos \frac{1}{2}m = CE$

2. It has already been shown in the proof of Theorem 4 that $CE = \sqrt{\frac{1+\cos m}{2}}$

Hence $\cos \frac{1}{2}m = \sqrt{\frac{1+\cos m}{2}}$

Of these geometric proofs, all but the first are open to the objection that the relationships are proved for the angles of a triangle, whereas the traditional proofs given in the usual trigonometry text are true for any angles. However, I believe that many pupils will be interested in seeing this new approach to these relations in spite of its limitations.

The geometric proof of the Law of Tangents presents several interesting considerations. In the opinion of the writer it is not more difficult to the pupil than the traditional proof found in the usual trigonometry text. At the same time it has several important pedagogical advantages. First, it permits the pupil to see much more clearly the meaning of the law. Second, since the geometric proof does not depend upon the sum and difference formulas, the Law of Tangents can be introduced early in the course of trigonometry and the pupil set to work in solving oblique triangles that depend on this law, immediately after the work on the right triangle. One of the chief difficulties in the traditional presentation of the subject matter of trigonometry is that after leaving the right triangle, the pupil is compelled to wade through a mass of theoretical matter before resuming the solution of the triangle. The practically-minded pupil frequently loses interest in the subject matter as a result of so much theory.

Furthermore, with the term so short, and the important and difficult work of the solution of the oblique triangle postponed to the latter part of the term, the teacher frequently finds that the pupils have not had sufficient drill in the different cases of the oblique triangle. The geometric proof of the Law of Tangents, because it can be introduced directly after the pupil has been taught the definition of tangent of an angle, can therefore partly overcome the objections to the traditional presentation of the subject matter as outlined above.

INTRODUCING SQUARE ROOT TO EIGHTH GRADE PUPILS

By H. Philip Barber
Wilson Junior High School, Charleston, West Virginia

A convenient and fascinating method of introducing square root to eighth grade pupils which tends to develop reasoning at the same time by the use of two tables follows:

$1^2 = 1$	$10^2 = 100$
$2^2 = 4$	$20^2 = 400$
$3^2 = 9$	$30^2 = 900$
$4^2 = 16$	$40^2 = 1600$
$5^2 = 25$	$50^2 = 2500$
$6^2 = 36$	$60^2 = 3600$
$7^2 = 49$	$70^2 = 4900$
$8^2 = 64$	$80^2 = 6400$
$9^2 = 81$	$90^2 = 8100$
$10^2 = 100$	$100^2 = 10000$

After introducing the two tables to the pupils, which as a rule, are known, the first from their knowledge of the tables, and the second by simple induction—which at the same time will prove valuable in later handling of periods in extraction of the root—attention is called to the various pairs, viz., 1^2 ends in 1 as does 9^2. 2^2 ends in 4 as does 8^2; 3^2 ends in 9 as does 7^2; 4^2 ends in 6 as does 6^2; 5^2 alone ends in 5, while 0^2 alone ends in 00.

Given a number preferably not to exceed four digits, a perfect square, to determine by inspection the square root.

Consider 4225. Upon examination of table 2, we see that 4225 lies between 3600(60^2) and 4900(70^2). If we are sure that 4225 is a perfect square, we may conclude that its root is 65,

since 5^2 alone ends in 5, and since to be 75, its square would have to exceed 4900.

Using a second example, give the root of 1444. This falls, in table 2, between $900(30^2)$ and $1600(40^2)$. We at once may narrow the field to two possibilities—32 and 38. Since 1444 is very near 1600, we select 38 as our root due to its nearness to 40. Prove by multiplying 38 by 38.

Another example, 5476. Between 4900 and 6400, we conclude its root is either 74 or 76. If the nearness to $4900(70^2)$ or $6400(80^2)$ is not obvious, subtract 5476 from 6400 and compare with the difference obtained with $5476-4900$. 74 is the desired root.

While the two tables are useful, they can be dispensed with in a second method, perhaps more mathematical, but less fascinating. It consists of trial and error and a suspecting process.

Consider 9604. Let us suspect that its root is 88, and divide 9604 by 88. The result is 109. Had 88 been the root, the quotient would also have been 88. Let us add the divisor to the quotient $88+109=197$. Dividing by two, we get 98, disregarding fractions. Test, now, 98 as a divisor, which we find to be the proper root. Had 98 not given a quotient of 98, we should have again added quotient to divisor and try again. With practice, the suspected root added to its quotient and divided by two will give the proper root at once, or at most, on the second trial.

Test 1764. Suspect 38, quotient 46, sum 84, root 42.

Test 1681. Suspect 12, (to exaggerate and to show the effectiveness of the method) quotient 140, sum 152. Second trial root 76. Quotient 22, sum 98; third trial root 49, quotient 34, sum 83, fourth trial root (the inevitable) 41. Even with the exaggerated suspected root, we required but four trials.

Extending the second method into use with imperfect squares the definition of square root is emphasized by the several dividings. As an example, extract the square root of 41 accurate to three decimal places. Beginning with any number will eventually lead us to the result, but 6 is the obvious starting point. $41\div6=6.833$; average of divisor and quotient: 6.416; $41\div6.416=6.390$; Av: 6.403; $41\div6.403=6.403$ Ans.

Similarly the square root of 2, when starting with either 1 or 2 as a divisor will give 1.5 as an average of quotient plus divisor. $2\div1.5=1.333$; Av: 1.416; $2\div1.416=1.412$; Av. 1.414; $2\div1.414=1.414$. Ans.

Noticeable is the fact that repeating decimals assert themselves prominently during the process with an imperfect square.

DRAWING AND ITS FUNCTION IN THE GENERAL BOTANY COURSE

By A. M. Johnson
University of California at Los Angeles

It is probably safe to say that wherever General Botany is taught some form of notebook is required of the students. In fact the keeping of a notebook has become an established feature of the methodology of all laboratory instruction. "The chief end of laboratory work," says a close student of laboratory methodology in the biological sciences,* "is to insure a better understanding and a more permanent retention of the material concerned;" and towards the achievement of that end the student's notebook plays a most important rôle.

We have long entertained the idea that the notebook should be a thing of use to the student, a source of reference, a check upon his own work, and not something perfunctorily done to meet a particular requirement of the course. We mean that the notebook should count for something; it should register the student's ability to do, to see, and to think, and as a measure of that ability it should receive proper credit in the grading system. To require a notebook only to disregard the effort put forth upon it is a practice we do not uphold.

To the end that the notebook may count for something, adequate and, indeed, persistent instruction is necessary. Our function in the laboratory is not merely to "explain" things, but to guide in orderly habits of procedure and of thinking. Is not order, system, at the root of the "scientific method?" If there is anything of educational value in the scientific method, then the laboratory is the place where the student's introduction to that method should have its inception. The mere jotting down of so many data without knowing their significance or relation to one another soon becomes a boresome task.

But the preparation of a creditable notebook requires time, and the time element is an important consideration in laboratory instruction. The general tendency is to lag behind schedule for covering a certain amount of subject matter, and any effort to hasten the progress of the work is at once reflected in the character of the notebooks—by which the progress of the class is measured. On the other hand elimination of some of the sub-

* Fred Carleton Ayer: The Psychology of Drawing. Warwick & York, Baltimore, 1916.

ject matter is as likely as not to upset our "scheme of things." A preferable method, it has seemed to us, lies in devising some scheme of improving our laboratory procedure, which will enable us to cover the work in less time without impairment of efficiency. Some suggestions along these lines are submitted in what follows.

One cause of the lag in the progress of the laboratory work can be attributed to the amount of drawing that is connected with almost every laboratory exercise in General Botany. This is a matter which merits serious consideration. Drawing is so intimately associated with all laboratory sciences that it has become a tradition, an "institution." But drawing as a medium, as a convenient tool or vehicle, as a means of expression, and as appropriate to a particular subject has received very little attention. As a botanical vehicle it is very much in need of repairs and of lubrication. Instead of advancing and improving with the development of new and improved educational methods it has rather gone backwards into a state of careless indifference. Even in our textbooks, which should be our models of excellence and appropriateness, it too often flaunts a discouraging mediocrity—a forceful refutation of the scientific method.

For some reason drawing is a nightmare to a good many students. It ought not to be. Dislike of drawing is not inherent in the student. Rather to draw is a part of his "inborn nature." His first childlike effort with a pencil was instinctively to scrawl a line. But somehow in the course of his development this instinctive "feeling" for a line is lost, until when he comes to us as a botany student he shrinks from it in dread. Why? Was the instinct taken out of him somewhere in his educational career? Needless to say when confronted with objects of botanical nature the instinct for the line must be reawakened by some device that will bring about a favorable reaction to the task of drawing. We should be in position to bridge that difficulty. Are we stretching the truth in saying that very few teachers of botany have ever taken the pains to prepare themselves in that one "skill" which more than any other we can think of is the most useful to them in the teaching of the subject?

Lest we be misunderstood we would interpose that we are not thinking of "art" here in the sense that some objectors would have it. Rather we are thinking of skill akin to that acquired by the wood carver in the use of, say, a knife, or by the

carpenter of the plane, which, in its full mastery only, enters the realm of art. Indeed art insinuates itself into every task well done, into every object we see and touch and use, into the very textbook we are using. It speaks from every tool and truss and automobile. We have in mind here the development of a modicum of what we like to call the craftsmanship of the science, through the medium of that facile tool, the lead pencil. We have in mind to help the student to become a fairly good draftsman, and thereby to develop in him that assurance, that confidence, which will enable him to accomplish more speedily and more creditably those drawing tasks that he is required to do. But we have in mind a further and more important aim, namely, to develop the student's power of analytical thinking, for which purpose no other single medium is as effective as is drawing. By analytical thinking we mean here the ability to discriminate between essentials and non-essentials, between what is relevant and what is irrelevant to a question; in other words, the ability "to see the point." Only in so far as drawing conforms to these fundamental principles will it have any real educational value.

Drawing in General Botany should be a means to an end, and the simpler it is the better. As a form of record it should convey precisely the idea or ideas, or "facts," that the question specifically calls for. The inclusion of any features not relevant thereto is so much waste of time and effort. Herein lies the value of drawing as a medium for training the student to discriminate between what is essential or relevant to the immediate question and what is not.

To illustrate the method of simplification of the drawing operation, let us suppose we are commencing the laboratory course with a study of the sunflower as a "pattern plant." Our "direction sheet" calls for a drawing of the entire plant. Now to the inexperienced beginner that task assumes the proportions of an insurmountable obstacle,—and right at the start! There is nothing simple about it. How represent that confusion of lines, that mass of details, and, besides, the third dimension, and have the result look at all like a sunflower! The futility of setting such a task before the student at the outset would appear obvious, and his failure should enlist our sympathy rather than our disapproval.

On the contrary the problem of the pattern plant is not as futile as the foregoing remarks would lead us to suppose. Failures of the sort just mentioned are due not only to the student's

lack of understanding of the import of the question but also to negligent instruction. Left to his own resources the student plunges into a hurried effort to make as exact a "reproduction" of the sunflower as he is capable of making. Obviously the making of an exact "reproduction" of the sunflower is not at all the question here. And it is the neglect or unwillingness to see this point that is at the root of such carping criticisms as "We are not teaching art but botany," directed at instruction in drawing in botany classes. However, we would not deny that a good course in botany can be given without attention to drawing.

Now the problem of the "pattern plant" involves a general situation characteristic of seed plants and fern plants, namely, the possession of a shoot system and a root system. That is the salient fact to be learned, and that is the only fact that the drawing should show. To bring out the fact in a drawing all that is necessary is to disregard every detail that is irrelevant to the question. When we have eliminated the irrelevancies the result will be a very simple sketch, a mere outline, yet the features that distinguish the sunflower will be present. We have arrived at our result by the method of analysis; we have analyzed the sunflower to see how it conforms to the general proposition; we have had a lesson in discrimination, in distinguishing between relevancies and irrelevancies, so important in all scientific work. In other words, we have been introduced to the "scientific method."

The type of drawing that will illustrate the points just mentioned we shall call an analytical, a diagrammatic, or a conventional drawing. It is a "general purposes" drawing. Besides, it is the simplest, the easiest, and the quickest to make. And it can be easily taught. But nothing is worth doing that is not worth doing well, and to do a thing well, be it ever so simple, we must have the proper tools. The main object is to get results, and to get the results we have in mind by the shortest and quickest road, there is no objection to using any and every tool convenient and suitable to the purpose. There should be no restrictions nor inhibitions put on ingenuity. Rather, ingenuity should be encouraged and rewarded. Fortunately for our purpose, the tools are very simple and inexpensive, and are generally a part of every botany student's equipment. Use them!

A model diagrammatic drawing of the sunflower is shown in Fig. 1. For the purpose here used it was traced in India ink. The

outline was made with a sharp 4H pencil, the plant being held in such a position as would lend itself to pleasing appearance and ease in drawing. The stem was drawn with the aid of a ruler for the sake of speed and neatness. Tracing drawings in India ink is left entirely to the inclinations of the student. Pen drawings require more time, and to be of any merit demand a skill and technique rarely possessed by beginners. In drawing with

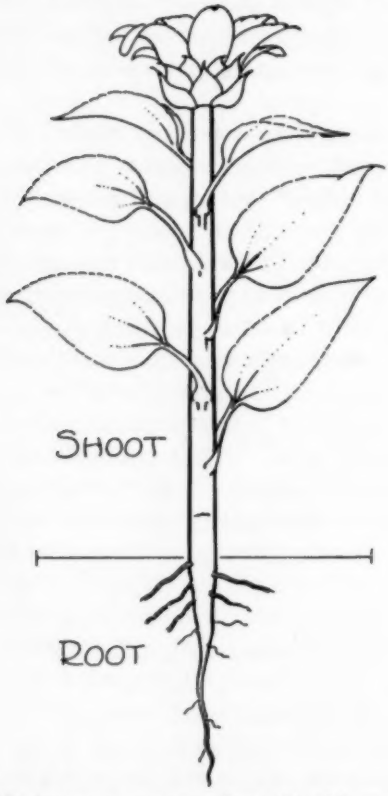


FIG. 1. The Sunflower as a pattern plant. In this case the "head" or flower-cluster at the top of the shoot is merely a contracted continuation of the shoot, wherefore the involucral bracts and the corollas of the "ray-flowers" are represented with some care. A mere suggestion of the principal veins of the leaves is given; their inclusion is entirely optional.

the pencil the character of the line will depend to a considerable degree upon the hardness and character of the pencil point. No restrictions need be placed on the thickness of the point, although some guidance may be advisable according to aptitudes. Beautiful lines can be made with a thick point, but the

line may be made to suit the occasion. The surest way to stifle a student's interest is to cramp his natural inclination, instead of developing his special aptitudes in drawing by a little judicious direction.

Not a little attention is required in adjusting the drawing to the size of the notebook page, especially for the purpose of leaving space for labeling—which must show precisely what the question called for. So many different ideas are in vogue as regards systems of labeling, all of which have merits, that the only remark we would make here is that the more direct the labeling is the better. We mean by that that the eye should not be made to wander by roundabout ways to reach the label.

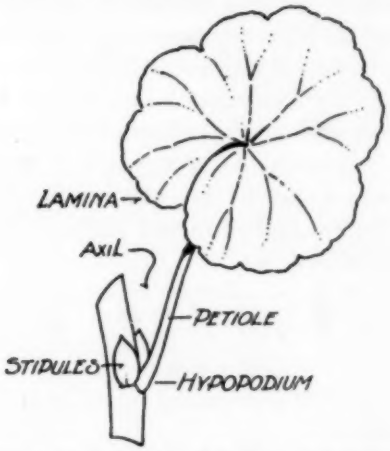


FIG. 2. The generalized type of leaf of the geranium, showing the principal elements in its organography. The veins could be further simplified.

The psychology of the learning process finds immediate application here, and we can derive profit from many pointed suggestions in this regard from the advertising columns of our newspapers and periodicals. Moreover, the time factor is as important a consideration in executing a system of labeling as it is in making the drawing.

The application of the diagrammatic drawing to another general situation may be illustrated by the exercise on "the morphology of the leaf." For this purpose we may have selected the leaf of the common potted geranium, this leaf being of the "generalized type." Again, we are here not concerned with irrelevant minutiae, such as pubescence, veinlets, etc., but only with those features of its organography which justify our classi-

fication of it as a "generalized leaf," namely the possession of a blade (or lamina), a leafstalk (or petiole), a base (or hypopodium), and stipules. Our interpretation is shown in Fig. 2. By way of contrast, and as a further discipline in the analytical method, we may at this point in the exercise introduce another leaf, one which lacks one of the features or parts possessed by the geranium leaf, and make a drawing of it in the same way. We might continue our analysis to other incomplete or "modified" leaves until we had a whole series.

It will be seen, then, that training in the making of analytical or diagrammatic drawings is discipline that leads straight to essentials. It is a discipline that reinforces our judgment of the relative values of the data we are discovering. A mere glance at such a drawing is sufficient to show whether or not its author had grasped the essential points of the problem. As a pedagogical instrument in the botanical laboratory it has no equal in compelling a student to analyze his problem to the end, in other words to think. It is particularly useful in morphological studies where comparisons and contrasts are involved. Its application to anatomical studies and to flower analysis will be treated in subsequent papers.

Helpful information of interest to teachers will be found in the following references.

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2. Cooper, Thomas H. *Good Pen Drawings*, Art Extension Department, The Cleveland School of Art, Cleveland, Ohio.
3. Jeffrey. *Plant Anatomy*, Chicago University Press. Contains many excellent examples of the effective use of diagrammatic drawings.

MEMORIZING e TO TWENTY-ONE DECIMAL PLACES

By Earl C. Rex, M.S.
Grays Harbor Junior College, Aberdeen, Washington

The logarithmic base e is useful in science and mathematics. To memorize this value to twenty-one decimal places, simply memorize the following rhyme. Each word represents a digit of the number, which is determined by the number of letters in the word. Of course, "nothing" and "Naught" represent zero.

In figures I searched to discover
A sequence in Mystery's knot;
Great Logarithm! nothing will recur
In thy realm but entity Naught!

$e = 2.718281828459045235360 \cdots$.

EFFECTIVE SCIENCE TEACHING

By William R. Winicov
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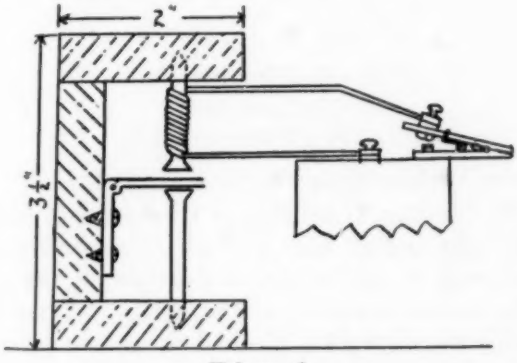
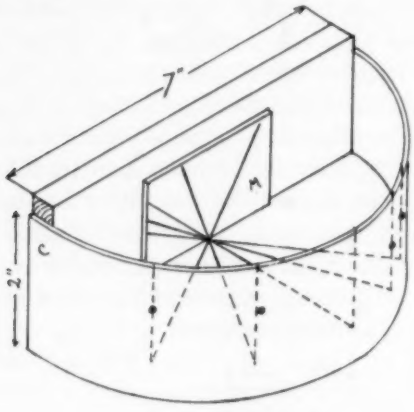
It no longer needs any argument to convince even the inexperienced science teacher that, everything being equal, the more senses we appeal to in our teaching, the more deeply will the subject matter impress itself upon the minds of our pupils. Nor is it any longer considered good pedagogy to merely "lecture" about natural phenomena. The pupils want to be shown; they want to see how the laws under discussion actually operate. Obviously enough, the clearer the proof the sooner and the more quickly will the pupils *understand*, leaving their minds free to memorize only those facts and formulae which are either incapable of proof in the average classroom, or are merely summaries of the facts and laws demonstrated.



Telegraph

Now in classroom demonstrations the science teacher must keep several significant points in mind: 1) The experiment must actually demonstrate what he intends to prove; 2) The apparatus must be of the simplest kind; 3) If possible the pupils must be encouraged to make the apparatus themselves, so that they can learn by doing. These points are now quite axiomatic. There only remains the problem of simplifying the apparatus used to such an extent that the students can easily understand its operation and be able to make it themselves. It is with this aim in view that the writer has devised and simplified the following pieces of apparatus, which have been used successfully in his classroom and which can and have been made by pupils.

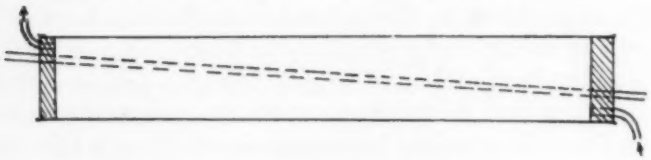
The simplest and easiest device to make is the electric telegraph instrument* which has been introduced into the Philadelphia eighth grade science course to the great joy of many boys, and some girls, who have copied and enjoyed it. The accompanying diagram is so clear that it speaks for itself, and requires no further comment.



Reflectometer
C.—Cardboard
M.—Mirror

The second easiest apparatus to make is the reflectometer* shown in the drawing. It consists of two pieces of board nailed together at right angles, with a small piece of mirror fastened with thumbtacks in the middle of the upright piece of wood. Around the semicircular end of the horizontal board there is fastened with thumbtacks a piece of cardboard provided with four tiny openings, at each of the thirty and sixty degree angles. To avoid fraying the apertures may be burned through with the straightened end of a paper clip heated to redness.

In operating this device the reflectometer is placed on the level of pupil's eye, and a candle flame held in front of one of the

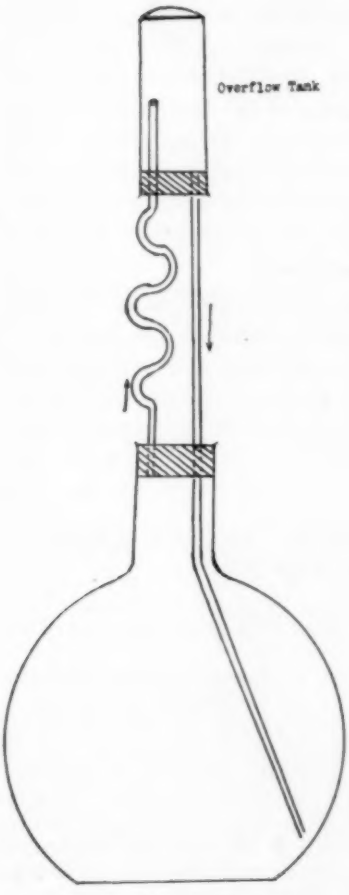


Condenser

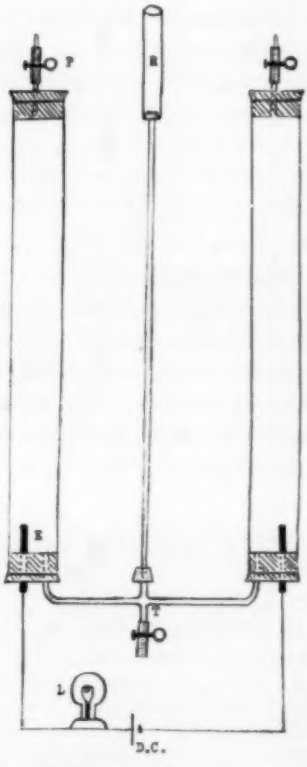
* The writer wishes to thank his colleague, Mr. Ellis Johnson of the industrial arts department, for his assistance in making the first models of these devices.

openings, say the sixty degree angle. The student is then asked to look into the other openings and find in which one the flickering flame is visible. It works perfectly, as the light can only be seen in the aperture of the corresponding angle on the other side, thus proving that the angle of incidence is equal to the angle of reflection.

The distillation apparatus is merely a home-made Liebig condenser. The large tube (18 or 24 inches long and one inch wide) may be ordered directly from any dealer in laboratory supplies or cut from a stock tube by filing a fairly deep groove around the tube at the desired point, moistening the groove slightly, and pressing against it the melted end of a thin glass rod. It is not



Convection Apparatus



D.C.—House current
L.—75–100 w. bull resistance
E.—Platinum or carbon electrode
T.—4 way tube
P.—Pinch cock
R.—Reservoir

necessary to perform the tedious task of melting the sharp edges of the hard glass tube; filing it gently with a triangular file on the outside and a rat tail file on the inside serves the purpose just as well, and lessens the chances of cracking the tube.

The convection apparatus offers but one difficulty, that of bending the worm tube—an obstacle which many a high school student can overcome at the cost of a few cents worth of tubing. But what joy they experience in doing it! The tube representing the overflow tank consists of the standard eight inch test tube with the bottom cut off as suggested in the construction of the condenser.

The home-made Hoffman electrolysis apparatus is the most complicated, yet not too difficult for the average high school boy to make. Here again the tubes (18 inches long and $\frac{1}{2}$ inch inside diameter) may be ordered from any supply house or cut from stock tubes as indicated above. The electrodes may be of gas carbon or platinum wire twisted around the end of copper wire and sealed into narrow glass tubing. Three clamps (not shown in the diagram) are needed to hold the apparatus in place, one for each of the side tubes, and one for the middle tube. The reservoir at the top of the middle tube is an eight inch test tube with the bottom cut off as described above.

It is hoped that the above suggestions will add to the efficiency of science teaching in many junior and senior high schools, will promote individualization of instruction, and perhaps help the rural teacher, who, because of reduced appropriations for supplies in these hard times, is forced to "talk" rather than teach science.

TESTS CONFIRM VALUE OF HIGH VOLTAGE X-RAYS IN TREATING CANCER

"Very high voltage X-rays will prove to be of great value in cancer therapy," stated Dr. G. Failla of New York City at the meeting of the American Congress of Radiology.

Dr. Failla described recent tests made at Memorial Hospital which showed that 700,000 volt X-rays are superior to 200,000 volt X-rays in treating internal cancer, and that radium is still better. Because of the expense, the full value of radium, however, cannot be realized in practice.

A method of expressing radium dosage in roentgens, the international unit of X-radiation, was also reported by Dr. Failla. The dose just large enough to produce reddening of the skin with a large beam of gamma rays from radium is 1,500 roentgens as compared to 540 roentgens required to produce the same degree of reddening with filtered 200,000 volt X-rays, research at Memorial Hospital showed.—*Science Service.*

IMPROVEMENT SHEET FOR PHYSICS

By Carl G. F. Franzén
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In the majority of high schools in the Middle West Physics is the most frequently taught science course. In too many instances students who take such a course do not receive advanced credit for it in college, and in too many other instances the course itself is taught on the college level or to meet college standards. The aims and objectives of the course then become about the same as those of the freshman course in college.

Surely in the light of current educational theory, this situation may well be challenged. If the purpose of this high school course in science should be to acquaint boys and girls of the adolescent period with the wonderful stories that nature has to tell them about the world in which they live, to gain a possible understanding of many of the phenomena which they see and of which they hear, and a possible insight into the scientific method, there is no reason for trying to make this course a duplicate of the usual freshman course in Physics taught in college. Consequently, a much better result might be obtained if the course were organized on the problem basis somewhat similar to such courses as are called Household Physics or Physics for Girls. If the problem method should be the one used, there would be some rather important changes in the organization of the content as well as the method of teaching the course. There would be a great deal of cooperation between teacher and pupils in selecting the problems to be investigated and in carrying on the investigations.

It is on the assumption that the method suggested above is one that will vitalize the teaching of high school Physics that the following Improvement Sheet in Physics has been devised, and that the term, class conference, has been used instead of class recitation. The organization of the Improvement Sheet also attempts to be an answer to the charges of those who are criticizing the work of the laboratory method. It should be noted that the problems that have been developed during the class conference are those that are to form the basis of the laboratory investigation and that, in turn, the results of the investigation are to be reported as part of the demonstration work when the answers to the problem have been outlined.

As in the two previous Improvement Sheets (Algebra in the

December, 1932, issue, and Geometry in the March, 1933, issue) the questions on the Improvement Sheet have been so worded that "Yes" always implies the performance of a desirable activity, whereas "No" implies its absence.

I. Aims

A. *To develop some skill in the manipulation of mechanical and electrical devices of everyday life.
B. *To help the pupil to a better understanding of those parts of his environment which can be explained in terms of the science of physics.
C. *To show the part which the science of physics has played in the development of civilization.

II. Class Conference

	Yes	*No*
A. Teacher Activities		
1. *Do the assignments stress phenomena which have been a part of the pupils' experiences?	____	____
2. Do the assignments stimulate pupils to set problems and to try methods of experimentation?	____	____
3. Is the class discussion on the same unit of subject matter as the class demonstration or experiment?	____	____
4. Does the teacher encourage informal participation in class discussion?	____	____
5. Does the teacher guide the pupil through reasoning to a solution of his own question?	____	____
6. *Are the principles of physics shown to apply to everyday life problems?	____	____
7. Is the scientific nomenclature made clear to the pupils?	____	____
8. Is the practical phase of the principles of physics given consideration?	____	____
9. Does the teacher encourage the use of the new technical terms that apply in class discussion?	____	____
10. *Are the great scientists given credit for their contributions?	____	____
B. Pupil Activities		
1. Do the pupils draw upon their own experiences to supplement the assignment?	____	____
2. *Do the pupils present outside experiences related to the problem?	____	____
3. Are the pupils' contributions directly related to the solution of the problem under discussion?	____	____
4. *Do the pupils propose problems based on field trip observations?	____	____
5. *Do the pupils freely contribute to the class discussion?	____	____
6. *Do the pupils suggest applications of physics to everyday life problems?	____	____
7. Do the pupils use correct scientific nomenclature in the discussion?	____	____

	Yes	*No*
8. Do the pupils organize the facts and principles gained from the conference and state them as clear and valid conclusions?	___	___
9. *Do the pupils ask questions?	___	___

III. Class Demonstration

A. Teacher Activities

1. *Does the teacher make a wise choice between experiments suitable for class demonstration and for laboratory practice?	___	___
2. Is the apparatus pre-assembled for class demonstration?	___	___
3. Has the teacher tested the apparatus before hand to assure himself that the demonstration will be a success?	___	___
4. Is the teacher skillful in manipulating the apparatus?	___	___
5. *Are sufficient problem situations introduced to produce effective use of the apparatus?	___	___
6. *Are the purposes of the demonstration made clear to the pupils?	___	___
7. *Does the teacher use demonstration to introduce new work?	___	___
8. *Does the demonstration create a problem situation?	___	___
9. Are the demonstrations of principles effective in provoking discussion?	___	___
10. *Does the teacher encourage the pupils to assist in the demonstrations?	___	___
11. *Do the field trips to local industries furnish problem material?	___	___
12. *Are the observations made on field trips related to some problem set up in class discussion?	___	___
13. *Are directions given to pupils for making observations on field trips?	___	___

B. Pupil Activities

1. Does the informal discussion indicate that the pupils understand the purpose of the demonstration?	___	___
2. *Do the pupils volunteer help in assembling the apparatus for demonstration under the guidance of the teacher?	___	___
3. Are the pupils curious about the arrangement of the apparatus?	___	___
4. Is opportunity given after demonstration for the pupils to examine the apparatus?	___	___
5. *Is opportunity given for demonstration?	___	___

IV. Laboratory

A. Equipment

1. *Is the apparatus in units readily accessible to the pupils?	___	___

	Yes	*No*
2. *Are workbench and tools for repairing and making apparatus by the pupils available somewhere in the school? In laboratory if possible.	____	____
3. Is there a definite place for every piece of apparatus?	____	____
B. Teacher Activities		
1. *Is the laboratory work a complement to class discussion?	____	____
2. Does the teacher change the size of the groups in the laboratory to conform to the demands of the particular experiment?	____	____
3. *Are the laboratory directions developed so clearly that the pupils are able to begin immediately?	____	____
4. Does the teacher discuss the use and care of the apparatus?	____	____
5. *Does the teacher teach the pupils how to study and use materials?	____	____
6. Does the teacher foster pupil initiative in the planning of suitable apparatus?	____	____
7. *Is the laboratory work motivated by opportunities to demonstrate the work in assembly programs?	____	____
C. Pupil Activities		
1. *Do the pupils seem to know what they are doing?	____	____
2. Do the pupils show ability to devise and adapt apparatus?	____	____
3. Do pupils show due care in handling apparatus?	____	____
4. Do the pupils take measurements accurately?	____	____
5. Do the pupils limit their conversation to the work at hand?	____	____
6. Do the pupils give evidence of applying principles learned in the laboratory to the physical phenomena in which they come in contact?	____	____
7. Are the pupils actively engaged?	____	____
V. NOTEBOOK		
A. Teacher Activities		
1. *Does the teacher require that the original data of the experiment be recorded during the progress of the experiment?	____	____
2. *Does the teacher require the following record of the experiment:		
a. The problem?	____	____
b. The purpose of the problem?	____	____
c. The assembling of the apparatus?	____	____
d. The procedure?	____	____
e. The data?	____	____
f. The conclusions?	____	____
3. *Does the teacher require the following record to be		

	Yes	*No*
placed in the notebook as the result of class conference on the experiment:		
a. The interpretations?	____	____
b. The sources of error?	____	____
c. The application?	____	____
4. *Does the teacher require such drawings, graphs, and calculations as are necessary for the interpretation of the experiment?	____	____
5. Does the teacher utilize the notebook in subsequent class conference?	____	____
6. *If the teacher grades the notebook does he do it on the basis of:		
a. Completeness?	____	____
b. Exactness?	____	____
c. Neatness? (See B-3 below.)	____	____
B. Pupil Activities		
1. *Do the pupils' conclusions show evidence of a knowledge of the purpose of the experiment?	____	____
2. Are the records of the current experiments left in the laboratory until the experiment is completed?	____	____
3. *Do the pupils keep their notes as neat as conditions will permit?	____	____
4. Do the pupils use the notebook to keep a list of frequently used technical terms?	____	____
5. Do the pupils record their laboratory and other assignments in the notebook?	____	____
6. Do the pupils record individual projects and reports in their notebooks?	____	____
VI. Supplementary Materials		
1. *Is the laboratory supplied with books, magazines, and other reference material?	____	____
2. *Do the pupils use the reference material?	____	____
3. *Are the bibliographies and works of noted physicists used as supplementary material?	____	____
4. *Does the teacher suggest supplementary experiments to provide for individual differences?	____	____
5. *Are there opportunities for making models and pieces of scientific apparatus?	____	____
VII. Field Trips or Excursions		
1. Do the pupils suggest field trips to be taken?	____	____
2. *Does the teacher then take pupils to places which show applications of practical physical principles?	____	____
3. Are field trips coordinated with the unit of work being studied?	____	____
4. Have the teacher and pupils made definite plans as to what to observe?	____	____

	Yes	*No*
5. *Are the results of the observation of the field trips used for subsequent class conferences?	____	____

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NEW RUBBER COMPOUND TO IMPROVE EXPOSED TELEPHONES

A new rubber compound which will withstand moisture for many years under the most adverse weather conditions has been developed by research chemists working in the Bell Telephone Laboratories. The rubber is to be used to prevent the ready entrance of moisture into telephone transmitters installed in exposed locations and will improve reception in markets, taxi stations, police boxes and harbor craft.

To keep moisture away from the thin aluminum diaphragm of the transmitter, a rubber membrane is interposed between the diaphragm and the mouthpiece. Such a membrane must be extremely thin and supple and it has been found cannot be thicker than about three thousandths of an inch. Rubber as thin as this has been commercially used for a long time, but its life at best has been from one to two years. The new rubber compound, tests have shown, does not deteriorate when placed for varying periods of time in a vessel of pure oxygen at a pressure of 300 pounds per square inch and a temperature of 158 degrees Fahrenheit.

When subjected to this test, poorly compounded rubber usually loses shape and deteriorates in less than one day.

Following the development of the rubber, engineers were called to invent a contrivance to mold the compound in the necessary thinness and shape. A highly polished steel mold is now used. The mold is shaped to the dimensions of the desired part, with allowance for the slight contraction which takes place in soft rubber when it cools to room temperature. A quantity of the plastic compound is inserted in the mold cavity, which is subjected to a pressure of several tons per square inch by a hydraulic press. Steam at 20 pounds per square inch is circulated about the mold. Under the pressure and heat the compound takes shape and becomes ready for assembly.

Used along with waterproof cord, the new compound has been installed and found successful aboard the U.S.S. Lexington and Saratoga in withstanding the effects of salt water.—*Science Service.*

PREDICTING ACHIEVEMENT IN PLANE GEOMETRY

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STATEMENT OF PROBLEM

Prognosis tests, vocational interest blanks, and other various predicting schemes and devices constitute, as a general rule, some of the most valuable aids to personnel officers in vocational and educational guidance. Instruments of prognosis are especially valuable in periods of economic depression, such as we are experiencing now, when economy is the paramount issue in practically all vocational and educational procedure. To guide an individual toward an occupation for which he is best adapted and to direct a potential student to the type of education or training for which he is apparently best fitted are economy measures in that they conserve the time, energy, and resources of industry, tax-payers, and educators on the one hand and those individuals being directed on the other. To guide high-school students toward courses and subjects in which they are likely to achieve a fair degree of success is no exception to this general principle. Arithmetic in the elementary school and mathematics in the high school are two of the most frequent sources of failure among school pupils. Each failure, when followed by a repetition of the subject, entails additional expense. Although realizing the many limitations of the prognostic procedure, the present study seems to be justified on the basis of an economy program, if for no other.

The problem of this study may be stated specifically as follows: (1) To determine the value of the Orleans Geometry Prognosis Test as an instrument for predicting achievement in plane geometry and (2) to discover the relative prognostic value of the Orleans Geometry Prognosis Test, the Terman Group Test of Mental Ability, teachers' marks in beginning algebra, and a combination of these instruments.

METHOD OF PROCEDURE

The data were collected over a period of two school years, 1929–30 and 1931–32. At the opening of the 1929–30 school

session the Orleans Geometry Prognosis Test, Form A, and the Terman Group Test of Mental Ability, Form A, were given to 67 pupils just beginning the study of geometry. At the opening of the 1931–32 school term the same tests were given to 128 pupils just beginning the study of geometry. At the close of each school year the Columbia Research Bureau Plane Geometry Test, Form A, was given to the same pupils. Also the teachers' marks in plane geometry and in beginning algebra were secured. Of the 195 pupils considered in the study, 53 were in four high schools, each having a school term of eight months. These pupils are hereinafter known as group I and are listed in Table I. Six high schools, each having a school term of nine months, furnished the remaining 142 students. These pupils are designated as group II and are listed in Table II.

TABLE I
PUPILS IN GROUP I

Name of School	*Year Tests Given*	*Number of Pupils*
Clay County Agricultural High School, Pheba, Mississippi	1931–32	16
Houston High School, Houston, Mississippi	1931–32	20
Union High School, Union, Mississippi	1931–32	9
Woodland Consolidated High School, Woodland, Mississippi	1929–30	8
Total Number of Pupils		53

TABLE II
PUPILS IN GROUP II

Name of School	*Year Tests Given*	*Number of Pupils*
Chickasaw County Agricultural High School, Buena Vista, Mississippi	1929–30	18
Houston High School, Houston, Mississippi	1929–30	19
Lee High School, Columbus, Mississippi	1929–30	11
Moss Point High School, Moss Point, Mississippi	1931–32	49
Okolona High School, Okolona, Mississippi	1929–30	11
Newton High School, Newton, Mississippi	1931–32	34
Total Number of Pupils		142

The method of the study is purely statistical and quantitative. Simple, partial, and multiple correlation coefficients are

used to show the influence of the several factors on achievement in geometry. Regression equations and standard errors of estimate have been employed as substantiating evidence.

STATISTICAL DATA

Two measures of achievement in plane geometry have been taken, namely, (1) scores on the Columbia Research Bureau Plane Geometry Test and (2) teachers' marks in plane geometry. Tables III through VI give some of the statistical detail for the interpretations which follow in the next section.

TABLE III
COEFFICIENTS OF CORRELATION BETWEEN INSTRUMENTS OF PROGNOSIS AND MEASURES OF ACHIEVEMENT FOR GROUP I

Instruments of Prognosis	*Columbia Test*	*Teachers' Marks in Geometry*
Orleans Geometry Prognosis Test	.698	.214
Terman Group Test of Mental Ability	.666	.288
Teachers' Marks in Algebra	.086	.388

TABLE IV
COEFFICIENTS OF CORRELATION BETWEEN INSTRUMENTS OF PROGNOSIS AND MEASURES OF ACHIEVEMENT FOR GROUP II

Instruments of Prognosis	*Columbia Test*	*Teachers' Marks in Geometry*
Orleans Geometry Prognosis Test	.427	.521
Terman Group Test of Mental Ability	.400	.479
Teachers' Marks in Algebra	.531	.546

In the data on the following page the subscript

1 represents either the scores on the Columbia Research Bureau Plane Geometry Test or teachers' marks in geometry;
2 represents the scores on the Orleans Geometry Prognosis Test;
3 represents the scores on the Terman Group Test of Mental Ability; and
4 represents the teachers' marks in algebra.

The regression equations are given should the high-school teacher or principal have occasion to predict the individual scores in plane geometry for a given class or school. These equations will be of value also in the interpretations which follow. In the equations containing three or more variables the

TABLE V

COEFFICIENTS OF MULTIPLE CORRELATION FOR GROUPS I AND II COLUMBIA TEST (1) BEING TAKEN AS MEASURE OF ACHIEVEMENT

Measures Correlated	*Group I*	*Group II*
$R_{1.23}$	.733	.438
$R_{1.24}$	.701	.497
$R_{1.34}$	.676	.493
$R_{1.234}$	.747	.505

TABLE VI

COEFFICIENTS OF MULTIPLE CORRELATION FOR GROUPS I AND II TEACHERS' MARKS (1) BEING TAKEN AS MEASURE OF ACHIEVEMENT

Measures Correlated	*Group I*	*Group II*
$R_{1.23}$	.289	.531
$R_{1.24}$	.410	.617
$R_{1.34}$	.436	.423
$R_{1.234}$	.436	.625

LIST OF REGRESSION EQUATIONS

DEPENDENT VARIABLE: COLUMBIA TEST $\bar{X}_1$

Equations for Group I	*Standard Error Estimate*	*Equations for Group II*	*Standard Error Estimate*
$\bar{X}_1 = .334X_2 + 6.14$	12.49	$\bar{X}_1 = .167X_2 + 16.05$	11.08
$\bar{X}_1 = .296X_3 - 4.40$	13.00	$\bar{X}_1 = .170X_3 + 8.65$	11.22
$\bar{X}_1 = .217X_4 + 11.72$	17.37	$\bar{X}_1 = .670X_4 - 26.66$	11.05
$\bar{X}_1 = .216X_2 + .146X_3 - 2.37$	11.86	$\bar{X}_1 = .116X_2 + .069X_3 + 11.77$	11.01
$\bar{X}_1 = .339X_2 - .017X_4 + 7.20$	12.43	$\bar{X}_1 = .111X_2 + .470X_4 - 18.59$	10.63
$\bar{X}_1 = .618X_3 - .391X_4 - 9.30$	12.91	$\bar{X}_1 = .251X_3 + .517X_4 - 44.57$	10.74
$\bar{X}_1 = .220X_2 + .192X_3 - .282X_4 + 15.59$	11.75	$\bar{X}_1 = .065X_2 + .062X_3 + .467X_4 - 22.18$	10.57

DEPENDENT VARIABLE: TEACHERS' MARKS IN GEOMETRY $\bar{X}_1$

Equations for Group I	*Standard Error Estimate*	*Equations for Group II*	*Standard Error Estimate*
$\bar{X}_1 = .524X_2 + 44.93$	8.74	$\bar{X}_1 = .169X_2 + 69.60$	8.68
$\bar{X}_1 = .066X_3 + 74.49$	8.57	$\bar{X}_1 = .169X_3 + 62.47$	8.93
$\bar{X}_1 = .502X_4 + 40.18$	8.25	$\bar{X}_1 = .735X_4 + 21.66$	8.52
$\bar{X}_1 = .0005X_2 + .066X_3 + 74.42$	8.56	$\bar{X}_1 = .124X_2 + .061X_3 + 65.81$	8.62
$\bar{X}_1 = .033X_2 + .463X_4 + 41.10$	8.15	$\bar{X}_1 = .108X_2 + .514X_4 + 31.70$	8.00
$\bar{X}_1 = .09X_3 + .774X_4 + 6.37$	7.99	$\bar{X}_1 = .528X_2 + .558X_4 + 25.78$	7.84
$\bar{X}_1 = -.005X_2 + .050X_3 + .436X_4 + 40.26$	8.06	$\bar{X}_1 = .069X_2 + .054X_3 + .509X_4 + 28.69$	7.94

weight of each predicting instrument in the sum total of the prognosis is indicated.

INTERPRETATION OF DATA

The validity of a prognostic instrument can be estimated by the correlation between the scores obtained in it and the marks in geometry at the end of the first half year or first year. If the correlation is high, the prognostic instrument is valid, and it serves the purpose for which it is intended. If the correlation is low, it is not valid. A coefficient of correlation of .90 or above is advisable for fairly accurate prognosis. Judging from the size of the coefficients in Tables III and IV, the Orleans Test is not sufficiently accurate for predicting achievement in plane geometry, defining achievement in this case in terms of the scores on the Columbia Test or in terms of teachers' marks. If one knew how to compute an accurate composite index of achievement by assigning weights to teachers' marks and to scores on the Columbia Test, it is possible that the Orleans Test might prove to be a more accurate prognostic instrument. In all fairness to the prognostic procedure and to the criteria and tests involved it should be stated that the instruments of prognosis considered here might correlate higher with other criteria of achievement which we have not yet discovered.

It is interesting to observe from Table III, showing schools having terms of only eight months, that the Orleans Test and the Terman Test predict the scores on the Columbia Test more accurately than they predict teachers' marks in geometry. However, in schools having terms of nine months (Table IV) each of the three prognostic instruments (Orleans Test, Terman Test, and teachers' marks in algebra) predicts teachers' marks in geometry with a greater degree of accuracy. For both groups of schools teachers' marks in algebra predict teachers' marks in geometry more accurately than the scores on the Columbia Test. This relationship is probably to be expected.

The coefficients in Tables III and IV show that the Orleans Test is not appreciably more accurate in predicting achievement in plane geometry than is the Terman Test or teachers' marks in algebra. With the exception of a slight inconsistency in teachers' marks in algebra there is very little difference between the relative validity of the three predicting instruments. It should be observed that none of these prognostic factors has a coefficient of .90 or greater. Further evidence of the relative

accuracy of these instruments of prognosis is given in the standard errors of estimate in connection with the regression equations. When the instruments of prognosis are considered singly in the order, Orleans Test, Terman Test, and teachers' marks in algebra, the standard errors of estimate for predicting the Columbia scores are 12.49, 13.00, and 17.37 for group I and 11.08, 11.22, and 11.05 for group II, respectively. These data should be interpreted to mean that there is very little to choose between the relative accuracy of the three instruments. The inconsistency indicated by teachers' marks in algebra for group I should be noted. The zero-order coefficients of correlation in Tables III and IV, involving teachers' marks in algebra, vary from .086 to .546, while the standard errors of estimate for groups I and II are 11.05 and 17.37, respectively. The coefficients of .388 and .546 in Tables III and IV, respectively, and standard errors of estimate of 8.25 and 8.52 (the smallest of the six comparable standard errors involved in predicting teachers' marks in geometry) indicate that teachers' marks in algebra is the most accurate of the three instruments in predicting teachers' marks in plane geometry. This relationship is probably to be expected.

The best combination of prognostic instruments is indicated in Tables V and VI. The zero-order coefficients of correlation between the Columbia scores is .698 for group I (Table III) and .427 for group II (Table IV), while the coefficients of multiple correlation between the Columbia scores and a combination of the Orleans scores and the Terman scores is .733 for group I and .438 for group II (Table V). The addition of a third factor in the prediction, namely, teachers' marks in algebra (4), increases the coefficient so slightly, becoming .747, that it is questionable whether the additional effort is worth while. In fact, it is doubtful whether the addition of Terman scores (3) or teachers' marks in algebra (4) is worth the effort involved. Tables V and VI indicate that a combination of all three of the prognostic instruments furnishes the best prediction. But even this combination does not furnish the desired accuracy, because in no case does the coefficient exceed .747. The order of validity or accuracy with which the various combinations of instruments predict Columbia scores, the first named being the most important, is as follows:

1. Orleans Test, Terman Test, and teachers' marks in algebra.
2. Orleans Test and Terman Test, with exception in group II.

3. Orleans Test and teachers' marks in algebra.
4. Terman Test and teachers' marks in algebra.

The effect of teachers' marks in algebra on predicting teachers' marks in plane geometry should be observed in Table VI. With one exception there is a tendency for the coefficient to be relatively high in those combinations containing teachers' marks in algebra (4).

CONCLUSIONS

In so far as this study is concerned the following conclusions seem to be justified:

1. Of the three prognostic instruments studied, the Orleans Test (specifically constructed for prognosis in plane geometry) is not appreciably more accurate than the Terman Test or teachers' marks in algebra.

2. It is probably to be expected that teachers' marks in algebra is the most accurate of the three factors in predicting teachers' marks in plane geometry.

3. A combination of the three prognostic factors gives the most accurate prediction of achievement in plane geometry. But the addition of the second or third factors affects the accuracy of the prediction so slightly that the additional work involved is hardly worth the effort.

4. Neither of the prognostic instruments taken alone nor all of them in combination predicts achievement in plane geometry with sufficient accuracy to warrant their use as the final and only factors.

5. The coefficients of multiple correlation given in Tables V and VI, the largest being .747, indicate that some rather important factors have not been discovered in this study. These additional predicting instruments of necessity must be discovered by a process of elimination. For example, in another study it was shown that arithmetical ability is not a significant or satisfactory factor in the prediction of achievement in plane geometry.[1] The following are several miscellaneous factors that probably have some influence on achievement in plane geometry: a pupil's school habits, such as, regularity of home work, attentiveness in the classroom, originality, initiative, perseverance, and so on; external factors that influence a pupil's school work, such as, opportunities for home study, number of hours of outside work, number of children in the family, attitude of the home toward school achievement, and many others.

[1] Dennis H. Cooke and Carl L. Fields, "The Relation of Arithmetical Ability to Achievement in Algebra and Geometry," *Peabody Journal of Education*, May, 1932. Pp. 355–61.

THREE CHEMISTRY TESTS*

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These tests are of the modified true-false type, open book, time limit.

In administering these tests give the class the following instructions. If a question is true, it must be so labeled; if it is false it must be corrected; a question to which nothing is done is counted as incorrect in scoring. You may use your textbooks, laboratory, manuals, notebooks, and any other helps you may have. Do not use your neighbor's brains, nor attempt to use the teacher's during the test. The time limit is twenty-five minutes.

It is surprising how the time limit of 25 minutes, with open books weeds out the poor from the good students. I used to give tests very similar to these with no time limit and closed books, and the sorting of the sheep and goats was nowhere nearly as well done as under the present scheme. There are never more than five true questions to a test—sometime only one or two.

Chemistry Test

1. Chemistry is derived from an Arabian word, because the ancient Arabians studied alchemy so thoroly.
2. The study of chemistry involves a study of the changes which matter undergoes.
3. The scientific attitude, as used by the chemist, consists in using facts peculiar to a given situation to support a foreign proposition.
4. Lavosier, through a carefully conducted set of qualitative experiments showed that the air was composed of at least two gases, oxygen and nitrogen.
5. The important factors in correct ventilation are correct temperature, and the maintenance of percentage of oxygen and of carbon dioxide at 21 and 0.04 respectively.
6. The air is still believed to be one of the elements.
7. The great French chemist, Lavoisier, introduced quantitative methods into chemistry, thereby enabling the phlogiston theory of burning to be verified.
8. Among the great achievements of chemistry is the modern bootleg booze industry.
9. The earth owes its atmosphere to the explosion of meteorites as they near the surface of the earth.

* Editor's Note. The tests are printed in the hope that many more teachers may be encouraged to prepare new type tests suitable for instructional purposes as well as for testing. The requirement that all false questions be corrected takes off some of the curse of that type of question and promotes intensive study during the test.—Frank B. Wade.

10. When the air is liquefied the molecules of oxygen and of nitrogen are crowded much more closely together; the resulting liquid is used as a commercial source of nitrogen and of oxygen.

11. The ancients, led by Aristotle, believed there were four elements, hot and cold warm and dry.

12. The chemist prevents waste by the more complete utilization of raw materials at the expense of possible by-products.

13. We can tell that the air has weight by feeling how heavy it is.

14. Of the 95 elements comprising the earth's crust, the three most abundant are, respectively, sodium, iron, oxygen.

15. The alchemists did the best they could to advance the science of chemistry.

16. The industries of our country have no particular use for the services of chemistry because they are so highly mechanized.

17. The ancients had a very good theoretical knowledge of chemistry but were unable to turn it to any practical account.

18. When the earth was first detached from the sun it had a perfectly smooth crust.

19. The carbon dioxide present in the earth's atmosphere will turn lime-water cloudy; it is a product of plant respiration.

20. Because the air has such a constant composition it is believed to be compound and not a mixture.

21. The oxygen-carbon dioxide cycle involves the use of carbon dioxide by animals and of oxygen by plants.

22. The air is composed approximately of 1/5 oxygen and 4/5 hydrogen.

23. The moisture content of the air varies with temperature, being less the higher the temperature.

24. The atmosphere forms a layer of uniform density some 10 miles thick about the earth.

25. The dust in the earth's atmosphere is an unmitigated nuisance.

1–5. Four common natural fabrics are cotton, linen, silk, and wool. Cotton and wool are animal fibers and are similar to proteins, while linen and silk are vegetable fibers and are carbohydrates. The animal fibers give much odor when they burn and are not dissolved by sodium hydroxide. The vegetable fibers are amphoteric, hence they are less readily attacked by chemical reagents. Linen is very hygroscopic, and because of this property, as well as due to the large amount of dead air space enclosed by the fibers makes the warmest fabric.

6. The cleansing of clothes by ordinary laundering is entirely a chemical process.

7. Direct dyeing is much more applicable to the animal fibers because of the greater chemical activity of those fibers.

8. Stains may be removed readily from fabrics after some time has elapsed, because the sun and air have already partially bleached out the stain.

9. In the tanning of leather a chemical change due to the mutual peptization of two colloids by each other takes place, which makes the finished product more pliable and less porous than it was before.

10. Rayon is a trade name for one kind of artificial silk which is a true synthetic silk.

11. Dalton's law of multiple proportions shows that chemical combinations must take place between whole atoms and never between fractions of atoms.

12. Nitrogen is a colorless, odorless, tasteless, very active gas, which forms 1/5 of the earth's atmosphere, and is an essential constituent of proteins.

13. On a commercial scale, as well as in the laboratory, nitric acid may be prepared by the action of sulfuric acid on sodium nitrate according to the following equation:

$$NaNO_3 + H_2SO_4 = NaSO_4 + HNO_3$$

14. Nitric acid is a colorless liquid, a powerful reducing agent, a very strong acid, and will dissolve gold and platinum.

15. Nitric acid may be made by the Ostwald process of the reduction of ammonia according to the following equation:

$$NH_3 + O_2 = HNO_3 + H_2O$$

16. Ammonia may be prepared by the action of a base upon some ammonium salt, or on a commercial scale as a by-product of the distillation of soft coal, or by the Ostwald process.

17. Ammonia is a colorless, odorless gas, sparingly soluble in water, and when dissolved in water it combines with the water to form the strong base ammonium hydroxide.

18. Ammonia gas is a valuable refrigerant because when liquefied ammonia is allowed to evaporate it extracts a great deal of heat from its surroundings.

19. Ammonium salts and salts of nitric acid are both valuable fertilizers because they supply hydrogen to the soil.

20. Nitric acid is used in the manufacture of explosives and in the preparation of various nitrated products because it is such a powerful reducing agent and strong acid.

21. and 22. How many grams of ammonia can be made by the reaction of 37 grams of calcium hydroxide with ammonium nitrate? How many liters will this ammonia occupy under standard conditions?

23. If an ammonium compound be treated with an acid ammonia gas will be evolved.

24. When a nitrate is treated with ferric sulfate and sulfuric acid a green layer is formed at the boundary of the two liquids.

25. How many grams of nitric acid could be made by the oxidation of 448 liters of ammonia gas by the Ostwald process?

ATOMIC WEIGHTS:

H—1, N—14, O—16, Ca—40.

1. Sulfur occurs in four allotropic forms: rhombic, prismatic, amorphous, and flowers of sulfur.

2. Hydrogen sulfide is a colorless, odorless, sour tasting, non-poisonous gas, moderately soluble in water.

3. Sulfur is a yellow solid resembling oxygen in physical properties and chemical conduct.

4. Sulfur dioxide may be produced by three methods: (a) by the burning of sulfur, (b) by the oxidation of sulfuric acid by a metal, (c) by the action of an acid on a sulfate.

5. The sulfate ion yields a yellow precipitate with the barium ion, the precipitate of barium sulfate being insoluble in hydrochloric acid.

6. Sulfur dioxide is the anhydride of sulfuric acid.

7. In the Frasch process of mining sulfur, the sulfur is melted by superheated water and forced up from the well by steam.

8. Sulfur dioxide is used for bleaching, as a disinfectant and preservative, and in the production of sulfuric acid.

9. Give the valence of sulfur in the three acids: hydrosulfuric, sulfurous, and sulfuric.

10. Sulfur is used as an insecticide; in the vulcanization of rubber; in the manufacture of gunpowder; and for the production of sulfur dioxide.

11. Sulfuric acid is used in the preparation of other acids because it is a good dehydrating agent; in the cleaning of metals because it is a good solvent.

12. Hydrogen sulfide is produced in the laboratory by the action of hydrochloric acid on ferrous sulfide according to the following equation

$$FeS+HCl\rightarrow FeCl_2+H_2S$$

13. Sulfuric acid, oil of vitriol, is made commercially by the contact process or by the chamber process, the catalyst for the contact process being oxides of nitrogen.

14. Sulfuric acid is a thick oily liquid, a powerful reducing agent, has a high boiling point, is a moderately strong acid, and is an excellent dehydrating agent.

15. The equations for the reactions in 4 are:

(a) $S+O_2\rightarrow SO_2$

(b) $2Ag+2H_2SO_4\rightarrow AgSO+2H_2O+SO$

(c) $NaSO_3+H_2SO_4\rightarrow NaSO_4+H_2O+SO_2$

16. The gram molecular weight, or mole, of a substance is the molecular weight of that substance expressed in grams and, if a gas, occupies 22.4 liters under standard conditions, which volume is called the gram molecular volume, or molar volume.

17–19. A small chemical industry consumes sulfuric acid at the rate of a ton a day. How much sulfur will be required to produce this quantity of sulfuric acid? If this acid is produced by the contact process, what weight of SO_2 will be formed? At the temperature of the reaction (400°C.) what volume will this quantity of SO_2 occupy if the pressure within the reaction chamber is 7600 mm.? (one pound = 450 grams).

20. The atomic weight of an element tells us how many times heavier the atom of that element is heavier than the atom of hydrogen on the basis of hydrogen = 1.

21. Standard conditions of a gas are 760 mm. of mercury pressure and 273° absolute temperature.

22. According to Avogadro's hypothesis equal volumes of all gases contain an equal number of molecules.

23. Compute the percentage composition of calcium carbonate.

24. Many gasoline saving compounds have been out on the market. One was recently analyzed and found to have the following composition:

Boron...728%; Lanthanum...92.08%; Hydrogen...0.66%

The molecular weight of this compound is 151; compute its formula.

25. According to Charles' Law, the temperature of a gas remaining constant, its volume varies inversely as the pressure.

THE SCIENCE PROGRAM IN SECONDARY EDUCATION*

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In a paper read before the Department of Science Instruction of the National Education Association meeting in Los Angeles in 1931, the words of Dr. Thomas H. Briggs were once more quoted by Dr. Ernest E. Bayles of the University of Kansas.[1] One phrase of this quotation will serve as an excellent text for what I have to say—"School people are limited in their competence, not so much in the details of their job, as in the larger comprehension of their significance. In other words, like the lay public, they need more than anything else, an understanding of what education is for, of the ends that it is supported to achieve." The purpose of this paper is to attempt to get the larger view of the science program for secondary education; to try to grasp the implications of present day trends in educational methods and thought and to endeavor to indicate in what direction development and improvement in science teaching seems most promising.

The problem of the best preparation and training of the college students who will be the science teachers in the high schools of tomorrow is one that confronts every thoughtful science teacher in college. Especially is this true in times of financial stringency like the present. The writer believes that the common practice of today in requiring a prospective teacher to major in one science and thereby, all too frequently, exclude from his program all other science work, tends to perpetuate in the high school organization the specialization and departmentalization of the college; whereas the exact opposite should be the aim.[2] Certainly, if we consider what will be the first work of the average college graduate in his teaching experience we realize this fact. For in all probability the only positions open to him will be in the smaller country high schools where he will be required to teach not one but several sciences. If his preparation is not broad enough to give him at least a sympathetic understanding and a wide comprehension of the whole field of science and of the interrelations of the various branches, his work will hardly be successful. From the standpoint of the Col-

* Read before the Faculty Science Club of Whitworth College, January, 1933.

lege then, the future high school teacher should have broad scientific training rather than specialized work in one department.

What will the conditions be that our college graduate faces when he obtains his first teaching position? One of the most striking, not to say dismaying, facts he will face is the decline in interest in science, in spite of the increasing applications of science in our everyday life. To cite but one instance of this tendency:—the enrolment in physics courses in the high schools of the country in 1910 amounted to 14.6% of the total enrolment in the schools. In 1928 this percentage was less than 7%.[3] These figures are an understatement rather than an overstatement of the facts since physics normally is a fourth year subject and the enrolment of the fourth year has been increasing much more rapidly than the total enrolment of the high schools. Statistics from many sources may be cited in support of this fact.[4] Evidently, if science teaching, so far as the high school is concerned, is to attract its due proportion of qualified teachers this condition must be remedied, and that speedily.

When we consider what factors have influenced or caused this drift away from science work, we find at least three prominent ones. The introduction of the General Science course has been an important factor. This is for two reasons. First: if the General Science course satisfies the local requirements for graduation, many students will take no other. Second: the subject matter of the General Science course consists at present so largely of material that is also treated in the more specialized science courses that interest in the latter flags and enrolment consequently drops. The proponent of the General Science work may reply, "All right, so long as the student has had one science course well and good." Unfortunately, we cannot agree to this, since the work in General Science is not in itself of sufficiently broad or thorough a nature as to be adequate training in science for to-day. One investigator[5] states that the average of five leading General Science textbooks shows its content to be divided as follows: 10% Chemistry; 38% Physics; 34% Biology; 18% Astronomy, Physiography, etc. The last named is probably not duplicated elsewhere in the school curriculum, but of the biological material only 2% was not found in the standard biology texts while 61% of the material was treated in identical fashion. Similar facts may be found for the other sciences as is instanced by another writer[6] who states that pupils who have

had general science are already equipped with 34.5% of the biology, 25% of the chemistry, and 41.4% of the physics that they will encounter in the textbooks on these subjects. Need we wonder at a falling off in interest in these subjects?

A second reason for the decline in interest in science may be found in the amount of mathematical preparation required,[4] particularly for the work in chemistry and physics. This unquestionably deters many students from taking work in these subjects even though a careful analysis of the mathematics actually required shows that only a few processes, and those not complicated ones, are needed.

A third reason for the condition noted may be found in the attitude of many college and university instructors, and in oft-quoted statements of so-called leading business men—usually of the "self-made" variety. It is all too common an experience to hear this or that one quoted as saying in effect that the scientific instruction and the knowledge thus imparted is of no practical value to the student in the business world, while the attitude of the colleges is evidenced by the fact that students in the introductory science courses in college who have had science work in high school are accorded treatment no different from those who have not had the work. Some instructors even go further than that—the writer knows of one instructor (head of his department) who openly preferred students who had not had science work in high school to those who had. That there is some justification for these extreme views is shown by a recent investigation at the University of Minnesota[7] which shows that, judged by the grades received at the end of the course, there is no marked difference in performance between the two classes of students, though tests at the beginning showed a very marked advantage in favor of those who had had science work. The investigator goes on to show that the probable reason for this lack of difference lies in the totally different treatment accorded the subject in the college textbooks as compared with its treatment in the high school texts, so that there would be the minimum "carry over" from one course to the other.

Another rather discouraging fact that our college graduate will note is that while the aims of the science educational program are quite well set out and fairly definite, the average course in the sciences does not attain these aims with any marked degree of success. This is mentioned with emphasis in the article referred to at the beginning of this paper.[1]

At this point we touch upon a delicate problem in the matter of determining the success or failure of a teaching program or method. The literature of the subject is rather full of reports of this or that investigator who frequently draws entirely unjustifiable findings from the data collected. I will make a detailed reference to one such report to illustrate what is meant.[8] This work was done some years ago in New York State in an attempt to measure the efficiency of instruction in high school physics. A test was devised consisting of 24 questions in mechanics and 12 in heat, which was then administered to 600 pupils in 28 different high schools. From the answers obtained the following conclusions were drawn:

(1) Assuming that the test calls for the facts that pupils should know, the results show that they have not acquired the facts.
(2) The size of classes has no bearing. (Classes varied from 3 to 31.)
(3) Pupils in the College Entrance curriculum did better than those in the Normal Preparatory, General, or Mechanical curricula.
(4) Fourth year students made higher grades.
(5) Marks assigned by teachers did not have a close relationship with the scores of the respective students.

The general conclusion drawn is that the efficiency of teaching of physics in these high schools is of a very low order. The accuracy of this conclusion and the validity of the investigation has been questioned by a well known worker in this field,[9] who has analyzed the 36 questions and the papers received as follows:

> . . . of the 36 questions 18 demanded recall of a name or term, 4 required recall of certain isolated facts, 7 were numerical problems requiring the recall of a specific formula and then its use in the solution and 7 were non-numerical and involved the application of principles.

Of the actual conclusions he says:

> The investigator evidently is measuring achievement in terms of ability to recall facts. He says "Successful achievement in any subject obviously implies the acquisition of the essential facts of that subject". . . . If this be the case, can thinkers be produced except by chance, when attention is centered only on the ability to recall? Charters stresses the need for training students to *think* (not to remember). This test requires the student to recall mere names while the advantage of recognition is with-held. e.g.: "What is the name of the unit of force which acting upon one gram of mass gives it an acceleration of one centimeter per second?"
>
> This criticism is leveled not only at this study, but also at a good many others which represent themselves to measure one thing but in reality measure only a small part of that thing or something else entirely. This study sets itself up as measuring the efficiency of high school physics in-

struction. In reality, it attempts the measurement of only an insignificant phase of the instruction. Yet the conclusions fail to recognize this fact.

In the formulation of tests it is high time that attention be given to the nature of the thing tested for and to the development of tests which are valid measures of such. The mere fact that a test has been given to a large number of students does not make it "scientific" because there is no insurance that it measures what it is supposed to measure. To be scientific the measure must determine with a reasonable accuracy the presence or the absence of the thing sought. If ability to recall facts is sought then the test should involve the ability to recall facts. But if thinkers are to be produced, then opportunity should be given in the tests for the display of the thinking the student will do when confronted by thought provoking situations.

The foregoing extract points forcibly to the unwisdom of relying too strongly upon a formal test and especially upon the errors that unwittingly may creep into the interpretation of any such test. As teachers we should be careful as to what deductions we draw from these tests and also examine critically the findings of others so as to be reasonably sure that their conclusions are justifiable. Particularly should this be true if any modification of the teaching program is to be based upon results drawn from material of this nature.

Another reason for quoting the foregoing at such length is that it serves to focus the attention upon the real basic aim of all our educational activities—thinkers and the training of youth to think correctly. We are all familiar with the very many studies that have been made of recent years into the aims of the educational program and of the suggested changes in curricula that have been made as a consequence. Those formulated by the Committee on Standards of the North Central Association are well known: The Health, Vocational, Avocational and Social Objectives. In an endeavor to translate these objectives into more concrete terms several studies have been made recently which are of great interest. Those from which I shall quote happen to come largely from the field of physics but similar ones may be found for the other sciences.[10,11,12] The results of these studies may be briefly summarized by stating that the detailed objectives, formulated along the lines of the general aims noted above, may be centered around four main heads: Knowledge (of certain fundamental facts and concepts); Appreciations (and attitudes of mind especially towards things scientific); Techniques; Habits and Skills. The findings of one group of investigators are worth while considering a little more fully.[13] This report is later than the others cited and, interest-

ingly enough, it confirms the other work in very striking fashion. The twelve major objectives that their study brought out are:

Habits of scientific thinking
Scientific attitude of mind
Knowledge which will give insight into the environment and make of it an organized whole instead of a lot of disjointed parts
Ability in use of the scientific method
Appreciation of the benefits of science
Knowledge of scientific facts
Desire for further knowledge
Habits of inquiry
Power to apply general knowledge to specific cases
Knowledge of appliances developed by science
Knowledge to satisfy natural interests in nature
Appreciation of the universal operation of natural law

We may safely accept the thesis then that a proper science program must be built around these objectives and must satisfy their requirements. Further—it should be so organized that the subject matter as presented to the pupil is suited to his needs, is adjusted to his mental powers and therefore possible of assimilation and provides within itself the motivating qualities that will make the subject interesting and will stimulate the pupil to further efforts. I believe we will agree that the present organization of the science work in our high schools leaves considerable of this still to be desired.

Before proceeding to suggest a possible solution of the problem I have outlined above, I wish first to present still another view of our educational program and one that because most of us have spent all our lives in these United States we tend to overlook. I refer to a comparison of our work with that in European countries. In general we may say that our high school graduates are one or two years behind the corresponding age groups in Europe. This is due to a variety of causes into which we have not time to enter to-day, but at least one of them is the lost time in the 7th and 8th Grades. Some studies place as high a figure as 40% of the time spent in these Grades as largely lost—being taken up with review of the previous years' work. This, of course, retards the development of the child and handicaps him, particularly in comparison with children of other nationalities.

This fact was one of the major reasons back of the 6–3–3 plan as a substitute for the 8–4 plan. However, the new plan is useless unless the content of the entire six years is reviewed in the

light of the new plan, its content and material re-arranged to the new conditions and a satisfactory program worked out. Too often we have hailed the Junior High School as the solution, in itself, of these difficult problems, without realizing that it is but one tool to be used in working out the proper solution. Three of the results of the introduction of the Junior High School are (1) the bridging of the gap between the 8th Grade and High School; (2) Elimination of lost time in the 7th and 8th Grades and (3) the raising of the level of instruction in the entire six years of the High School program. The importance of the last result cannot I believe, be overemphasized. The content of our formal science courses, methods of presentation, and arrangement of material have not, with one single exception, shown any great changes over those existing prior to the general adoption of the Junior High School program. The exception to which I refer is the growing tendency to organize the work into "units" instead of the older "logical" way. The introduction of general science has been accelerated by the Junior High School movement but it would doubtless have come without any change in organization and therefore should not be viewed as a "result" of the 6–3–3 plan. The regrouping of the subject matter into "units' is however a beginning step in the direction of reorganizing the science work along more correct pedagogical lines.

The trouble with the present situation, however, is that the general science work is largely a duplication of other courses and that, viewing the science program as a whole, there is no continuity of purpose, no linking up of the separate branches of science and presenting them as an organized whole, which is of such fundamental importance, and therefore the reorganization forced upon us by the Junior High School program will not be complete until we have critically examined and reworked our science materials into a congruent whole that shall present to the pupil's mind an ordered sequence, an essential unity and a comprehensive grasp of the whole sweep of science and its implications, rather than a little portion of knowledge regarding some small subdivision of the whole field.

Within the past three or four years, this problem insofar as it relates to the mathematics department has, I believe, been very successfully met. Workers at various Universities, notably at the University of Chicago,[14] have been engaged upon the problem for several years and there are now upon the market

several series of texts which envision the whole field of mathematics and present it in pedagogically correct order, disregarding entirely the old division into arithmetic, algebra and geometry. This reorganization is still so recent that its implications on the teaching of other subjects has not yet been realized. For instance, some of the ideas that were reserved for the final years of high school work in mathematics are now introduced in the 7th and 8th Grades or wherever the pupil is capable of grasping at least a portion of them. Among these might be mentioned the elements of the theorem of Pythagoras, simple mensuration of areas and solids, etc., introduced in the 8th Grade, trigonometric ratios introduced in the 9th Grade, etc. If and when these revised textbooks and courses secure a wide adoption, the result should be a better preparation in mathematics on the part of the average pupil, this will at once remove in whole or in part the objection to science work on the ground of mathematical difficulty. It will also make possible the earlier introduction of material that requires mathematical handling and will in fact provide the mathematics teacher with motivation material from the science work and vice versa. This newer presentation of mathematics, of course, is based throughout upon the "unit" plan instead of the older "logical" method of presentation. Further, the material is arranged within each unit in a pedagogically sound order as well as each unit being placed in its proper pedagogical relationship to its fellows. Thus there is built up a thoroughly coherent, logical, development of the whole field of mathematics from the fundamentals of arithmetic through solid geometry and trigonometry.

The essential nature of mathematics and its applications to the study of any of the sciences is well recognized and is being emphasized still more.[15] With a properly organized mathematics program the way is clear for a reorganization of the science program. Any such reorganization to meet the needs of our modern world must be more than a mere "re-hashing" of the contents of the several sciences. It must be a thorough-going integration of the whole field of science that will provide the student with a course of study extending not through one or two years but through all six years of the Junior and Senior High School (and should ultimately be extended on down through the six primary years) that will present the essential facts, principles and laws, and also enable the pupil to obtain an intelligent understanding and appreciation of their applications to

modern life. In this connection let me quote a few sentences from the remarks of an Englishman who spent a year here investigating the work in general science:[16]—He found first class buildings and equipment but "secondrate personnel and insufficient training." He says "there is yet no six year plan, let alone a twelve year plan of school science, although I found some pioneer attempts in this direction, etc."

Summarizing the situation as it now exists, what do we find? An ideal of science education that is sound and good but that is poorly attained if indeed it be really attained at all. A waning interest in science work in the high schools, due to factors which are not insuperable but which as yet have not been met successfully. A school system, now in the process of revision, which when complete will markedly affect the entire program of study and especially the work in science. The keystone of an effective revision of the science courses is already prepared in the form of an effective course in mathematics upon which it will be possible to build an integrated, living, teachable and interesting program of science instruction.

As those engaged in the business of training those who will be teaching, as those who are preparing to teach or to teach more effectively and still more as those who are engaged in the very process of teaching, this situation constitutes a challenge and an opportunity for constructive work of the very highest order. Work that should go far towards re-establishing the teaching of science and the interest in science on its old footing and that will in future years provide a better trained and a more appreciative young manhood and young womanhood in this our country.

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INVERSE-SQUARES

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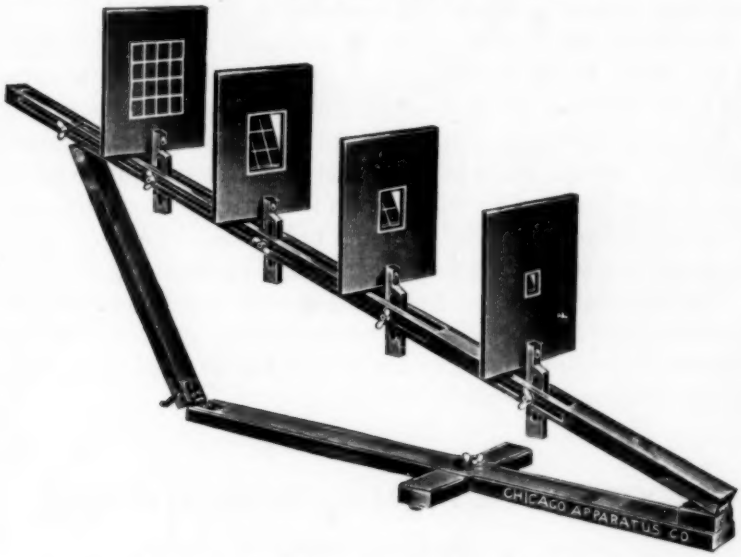
The apparatus here described is intended for use in the derivation of a law of light which was first formulated by Kepler (1571–1630). It is commonly referred to as Kepler's Law of Inverse Squares and may be stated: the intensity of illumination of a surface varies inversely as the square of the distance from the source of light.

Previously it has been the practice of the writer to present this relationship in the manner described in many textbooks, by the use of cards held in the hand or in ring-stand clamps. The objections to this method are: that the arrangement is make-shift, it is consumptive of time in set-up and adjustment, and accurate measurement of distances is difficult.

The system consists of the supporting structure and the four screens. The former is constructed so as to permit the ad-

justment of the screens in three dimensions. The first three screens have at their centers, doors which disappear by folding backwards. These doors are lined into areas of one, four, and nine square inches respectively. The last screen has no door but has a lined area of sixteen square inches. The accompanying illustration should clarify detail of construction.

The light source may be either an incandescent lamp, flashlight, projection lantern, or optical disk illuminator.



In use, a beam of light from a known distance is thrown on the first screen, near its center. This is allowed to pass through this screen at the aperture which may be created by folding back the door. By adjustment of the second screen, the lighted area can be "framed" to coincide with the four lined squares on that screen. The second screen will upon measurement be twice the distance from the source as the first. Similarly, when the beam is caused to pass on to screen three by folding back the door on the second screen, the new illuminated area can be adjusted to coincide with the nine lined squares on that screen. The last screen receives the light coming through the aperture in screen three and the sixteen lined square will be illuminated upon proper adjustment.

Thus, at

1 distance, the illumination is 1 unit area, $1^2=1$
2 distances, " " " 4 unit areas $2^2=4$

3 distances, the illumination is 9 unit areas, $3^2=9$
4 " " " " 16 " " $4^2=16$

Since the illumination decreases, the ratio is obviously an inverse one, so that on screen one the intensity per unit area is as one is to one; on screen two, as one is to four, and so on.

The device permits the illustration of a variety of separate relationships between intensity and distance. In any of these the successive use of the four screens has the values of sequence and repetition accruing to the teaching of the principle.

Because of the flexibility, the apparatus is visible in all parts of the room. If the light source is of relatively high intensity, the room need not be darkened during the demonstration.

Economy of time is a factor in its use, because having made the initial set-up, there is no further need for readjustment in succeeding classes. Often during an inductive presentation the principle is understood by students before they can come upon the necessary terminology for its intelligent statement.

The idea of divergence of the light may be shown by permeating the spaces between the screens with chalk dust from blackboard erasers, or by introducing a jet of smoke, and the spreading shaft becomes visible by reflection.

PROOF OF THE PYTHAGOREAN THEOREM

By Irving Saxe
Hartford, Connecticut

The following proof of the Pythagorean theorem depends on two preliminary theorems:

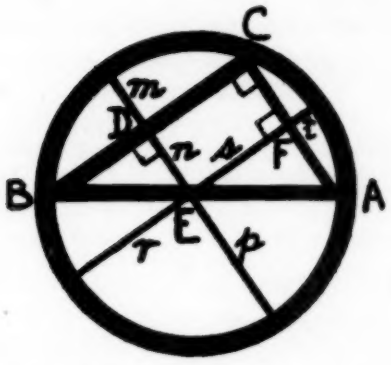
A. If a circle is drawn having as center the mid-point of the hypotenuse of a right triangle, the circle circumscribes the triangle.

This is not a formal proposition but may readily be proven by means of the fact that the diagonals of a rectangle bisect each other.

B. If two chords intersect inside a circle, the product of the segments of one equals the product of the segments of the other.

This theorem, as given in most geometry books, follows the Pythagorean Theorem. It is, however, altogether independent of it.

Theorem: *In a right triangle, the square of the hypotenuse equals the sum of the squares of the legs.*



Given: Right triangle ABC, C the right angle.
To Prove: $a^2+b^2=c^2$.

PROOF: Through the mid-point of c draw a circle. Then, by Theorem A, a and b are chords.

Now draw two diameters, one perpendicular to a and one to b, thus bisecting the chords, for a diameter perpendicular to a chord bisects it.

$(\frac{1}{2}a)(\frac{1}{2}a)=m(n+p)$ and
$(\frac{1}{2}b)(\frac{1}{2}b)=t(r+s)$, by Theorem B.

Now,

$\frac{1}{2}c=m+n$ $\qquad$ $\frac{1}{2}c=s+t$
$m=\frac{1}{2}c-n$ $\qquad$ $t=\frac{1}{2}c-s$

Also,

$p=\frac{1}{2}c$ $\qquad$ $r=\frac{1}{2}c$

Substituting,

$\frac{1}{4}a^2=(\frac{1}{2}c-n)(\frac{1}{2}c+n)$
$\frac{1}{4}b^2=(\frac{1}{2}c-s)(\frac{1}{2}c+s)$

Or,

$\frac{1}{4}a^2=\frac{1}{4}c^2-n^2$ $\qquad$ $\frac{1}{4}b^2=\frac{1}{4}c^2-s^2$

That is,

$a^2=c^2-4n^2$ $\qquad$ $b^2=c^2-4s^2$

And

$a^2+b^2=2c^2-4n^2-4s^2$

Now $CDEF$ is a rectangle (by construction) and so

$s=\frac{1}{2}a$ $\qquad$ $n=\frac{1}{2}b$

Substituting,

$a^2+b^2=2c^2-4(\frac{1}{2}b)^2-4(\frac{1}{2}a)^2$

From which

$a^2+b^2=c^2$, Q.E.D.

Nothing can be loved and hated unless first we have knowledge of it.—LEONARDO DA VINCI.

He that can have patience can have what he will.—FRANKLIN.

ANNUAL CONVENTION, CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, DECEMBER 1 AND 2

Congress Hotel, Chicago, Illinois

GENERAL PROGRAM

FRIDAY, DECEMBER 1, 1933

Registration, Lobby, Florentine Room, 8:00–9:00

Music—8:45–9:30. Lane Technical High School, Chicago, Illinois.

Address of Welcome—Dr. William J. Bogan, Superintendent of Schools, Chicago, Illinois.

Response for the Association—Dr. J. S. Georges, Hirsch High School, Chicago, Illinois.

Address—Dean Charles S. Slichter, Dean of the Graduate School, University of Wisconsin.
Subject: Mathematics and Reality.

Address—Dr. Francis D. Curtis, Professor of Secondary Education and of the Teaching of Science.
Subject: Some Effects of the Depression Upon the Teaching of Science.

LUNCHEON

RECEPTION AND DINNER

FRIDAY EVENING 5:00 P.M.

The Annual Reception will be held in the French Room of the Congress Hotel. Mrs. E. O. Bower, chairman of the reception committee, designates all Past-Presidents and officers of the Association as hosts for the occasion.

Annual Dinner—6:30 P.M.—Gold Room.

Tickets for the annual dinner will be $1.50 and should be secured at the time of registration. An interesting program under the direction of Oscar W. Anderson, Lane Technical High School, will be furnished.

Send reservations to Geo. E. Hawkins, University High School, University of Chicago, Chicago, Illinois.

The address of the evening will be delivered by

DR. CHARLES HUBBARD JUDD
Chairman, Department of Education
University of Chicago

Address—"Scientific Thinking Contrasted With Memorizing Scientific Facts."

SATURDAY MORNING, DECEMBER 2, 1933

Annual Business Meeting—8:30–9:30 A.M.

1. Reports of Committees.
2. Unfinished and new business.

GENERAL SESSION—9:30 A.M.

GOLD ROOM

Music—9:00–9:30. Roosevelt High School, Chicago, Illinois.

Address—Charles H. Lake, Superintendent of Schools, Cleveland, Ohio.
Subject: Looking Ahead in Science Teaching.

Address—Dr. Ernst R. Breslich, Associate Professor of the Teaching of Mathematics, University of Chicago.
Subject:

Address—Dr. Arthur H. Compton, Professor of Physics, University of Chicago.
Subject: Cosmic Rays (Illustrated).

SATURDAY, DECEMBER 2, 1933

NOON

LUNCHEON—12:30 P.M., CONGRESS HOTEL
ROOM

This luncheon is given in honor of newly-elected officers. Hence all members are urged to attend.

Newly-elected general officers and sectional officers and members of the Board of Directors will meet for a business meeting after the luncheon.

SECTIONAL MEETINGS

FRIDAY, DECEMBER 1, 1:30 P.M.

BIOLOGY

CONGRESS HOTEL WALNUT ROOM

Appointment of Nominating Committee.
Classroom Tests in Biology.
Dr. P. W. Holaday, Shortridge High School, Indianapolis, Indiana.
Tricks of the Trade.
O. D. Frank, University High School, University of Chicago, Chicago, Illinois.
General Discussion.
Election of Officers.

CHEMISTRY

CONGRESS HOTEL, ROOM 1162

Appointment of Nominating Committee.
The Chemical and the Baking Industry.
Victor Marx, Technical Editor, "Baker's Helper," Chicago.
High School Industrial Chemistry.
E. G. Pierce, East Technical High School, Cleveland, Ohio.
The Chemistry Teacher and the Reduced Budget.
Dr. B. F. Hopkins, University of Illinois.
Election of Officers.

ELEMENTARY SCIENCE

CONGRESS HOTEL, ENGLISH ROOM

Appointment of Nominating Committee.
The Teacher's Approach to the Problems in Teaching of Elementary Science.
Ira C. Davis, University High School, Madison, Wisconsin.
In Which Grade Should the Solar System and Its Relation to the University be Taught?
Theodosia Hadley, Western State Teachers College, Kalamazoo, Michigan.
Camping, an Important Part of a Child's Experience in Elementary Science. Illustrated.
Dr. William G. Vinal, School of Education, Western Reserve University, Cleveland, Ohio.
Election of Officers.

GEOGRAPHY

CONGRESS HOTEL, ROOM 1102

Appointment of Nominating Committee.
Organization of Materials for Teaching High School Geography.
Alice Foster, formerly teacher of geography, University High School, U. of C., Chicago, Illinois. 30 minutes
A Tentative Course in Political Geography.
Katharine Calloway, teacher of geography, Calumet High School, Chicago, Illinois. 10 minutes
Nationalism and Regional Planning: Their Relation to Secondary Geography.
J. Russell Whitaker, Assistant Professor of Geography, University of Wisconsin. 30 minutes
Individual Field Work in a Rural Community.
Clinton Rich, Milwaukee, Wis. 15 minutes
Election of Officers.

GENERAL SCIENCE

CONGRESS HOTEL, ROOM 1120

Appointment of Nominating Committee.
Techniques for Pupil Participation.
James E. McDade, Asst Superintendent of Schools, Chicago, Illinois.
How Much Should the Science Teacher Tell?
O. D. Frank, School of Education, University of Chicago.

(*concluded on page 918*)

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS OF PROBLEMS

Note. Persons sending in solutions and submitting problems for solution should observe the following instructions:

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

1286. *Proposed by Norman Anning, University of Michigan.*

The number N consists of p digits each of which is 6. Discover the nature of the product $N(N+1)$. Give a proof which is valid when N is any positive integer.

Solved by Allen E. Andersen, Wagner College, New York

We notice that $6\times7=42$, $66\times67=4422$, etc. In general, $N(N+1)$ is an integer of $2p$ digits. Each of its first p digits is 4 and each of the last p digits is 2.

To prove this we use the following notation, for convenience and compactness.

Let $a_0=1+10+10^2+\cdots+10^{p-1}$

$a_1=10+10^2+\cdots+10^p$, etc.

Then we may write $N=6(10^{p-1}+10^{p-2}+\cdots+10+1)=6a$.

We must prove that $N(N+1)=4(10^{2p-1}+10^{2p-2}+\cdots+10^p)+2(10^{p-1}+\cdots+10+1)=4a_p+2a_0$. We have $N(N+1)=6a_0(6a_0+1)=36a_0^2+6a_0$.

But $36=3\cdot10+6$ and a_0^2 may be written $(1+10+10^2+\cdots+10^{p-1})a_0=a_0+10a_0+\cdots+10^{p-1}a_0=a_0+a_1+a_2+\cdots+a_p$.

Hence $N(N+1)=(3\cdot10+6)\ (a_0+a_1+\cdots+a_{p-1})+6a_0$

$=3(a_1+a_2+\cdots+a_p)+6(a_0+a_1+\cdots+a_{p-1})+6a_0$

$=9a_1+a_2+a_3+\cdots+a_{p-1})+3a_p+12a_0$

$=[10a_0+9(a_1+a_2+\cdots+a_{p-1})]+3a_p+2a_0$.

By definition of the $a_0, a_1, \cdots$, we have $10a_0=a_1$, $10a_1=a_2$, etc. Therefore the expression in brackets reduces to just $10a_{p-1}$ and we have $N(N+1)=4a_p+2a_0$, which was to be proved.

Also solved by W. E. Buker, Leetsdale, Pa., Charles W. Trigg, Los Angeles, Calif., John W. Turkey, New Bedford, Mass.

1287. *Proposed by Charles W. Trigg, Cumnock College, Los Angeles.*

If the three sides and the area of a triangle are integers, at least one of the altitudes is an integer.

Discussion by the proposer

This problem is discussed in the American Mathematical Monthly, *27*, 38, Jan. 1920. There it is pointed out that the statement is not generally true since the triangle with sides 5, 29, and 30 has an area of 72 and altitudes of 144/5, 144/29, and 24/5.

In Carmichael's "Diophantine Analysis," p. 12 it is stated: "A necessary and sufficient condition that rational numbers x, y, z shall represent the sides of a rational triangle is that they shall be proportional to numbers of the form $n(m^2+h^2)$, $m(n^2+h^2)$, $(m+n)(mn-h^2)$, where m, n, h are positive rational numbers and $mn>h^2$."

In arriving at this conclusion it is noted that if $x=n(m^2+h^2)$, $y=m(n^2+h^2)$, and $z=(m+n)(mn-h^2)$, the area is $hmn(m+n)(mn-h)$ and the altitude upon $z=2hmn$. If m, n, and h are integers $(mn>h^2)$ a series of triangles is secured for which the statement is true.

1288. *Proposed by C. C. Hunt, Cedar Rapids, Iowa.*

In the following equation find the value of x and supply the missing digit represented by the dot.

$$[11(492+x)]^2=37.10201$$

Solved by the proposer

The solution depends on the fact, seen by inspection that 11 is a factor in both sides of the equation. Every number of which 11 is a factor has the property that the sum of the alternate digits is equal to the sum of the other digits. Thus the sum of 1, 2, 1 & 7 is 11. The sum of the other digits is 3. Therefore the missing digit must be 8. When this is supplied the number becomes 37810201. Extracting the square root of this gives 6149. Divide by 11 and the equation is reduced to

$$492+x=559. \text{ Therefore } x=67.$$

Note by Editor: Several in submitting solutions point out that, there being no restriction to an integral solution, the problem is indeterminate.

Other solutions are by John Ballards, St. Nazianz, Wis., Charles W. Trigg, Los Angeles, Calif., Cecil B. Read, Wichita, Kansas, W. E. Buker, Leetsdale, Pa., and John W. Turkey, New Bedford, Mass.

1289. *Proposed by G. C. Lentini, Boston, Mass.*

The volume of a right circular cylinder increases at the rate of m cubic centimeters per second. If at each instant, the volume is a maximum for the instantaneous total surface, find the rate of increase of the surface area.

Solved by W. E. Buker, Leetsdale, Pa.

It is known, that for the right circular cylinder of fixed total surface having a maximum volume, $h=d$. The cylinder considered in this problem will have that property.

Then $V=2\pi r^3$; $S=6\pi r^2$ (S = total surface; V = volume; $h=2r$).

Differentiating with respect to time,

$$\frac{dV}{dt}=6\pi r^2\frac{dr}{dt}, \tag{1}$$

$$\frac{dS}{dt}=12\pi r\frac{dr}{dt} \tag{2}$$

But $\dfrac{dV}{dt}=m$.

Hence, from (1), $\frac{dr}{dt}=\frac{m}{6\pi r^2}$.

Substituting in (2),

$$\frac{dS}{dt}=12\pi r\ \frac{m}{6\pi r^2}=\frac{2m}{r}, \text{ rate of change of surface area.}$$

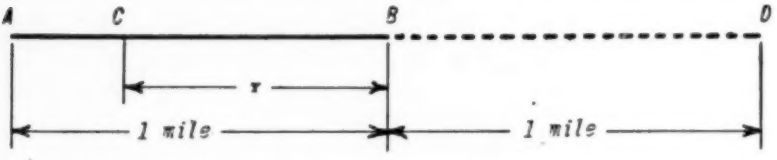
Also solved by Cecil B. Read, Wichita, Kan., Charles W. Trigg, Los Angeles, Calif., John W. Turkey, New Bedford, Mass., and the author.

1290. *Proposed by O. L. Darner, Scott City, Kansas.*

A captain on horseback stood at the head of a one mile column of soldiers. As the soldiers started forward the captain started toward the rear of the column. Upon arriving at the rear of the column he immediately turned and started toward the head of the column and when he arrived at the head of the column the soldiers had marched exactly one mile. If it took the soldiers 17.2683 minutes to march the mile, how far did the captain travel, if both rates are constant?

Solved by William W. Johnson, Cleveland, Ohio

Let AD be a straight line 2 miles long, and B its middle point. At starting, let the rear of the column of soldiers be at A, and its head at B; at the end of the one mile march the head will be at D, and the rear at B.



Let C be the point where the captain turns. The rates of marching of the column of soldiers and the captain, being uniform, will be proportional to the distance traveled by them in the same time.

Then we have $\frac{\text{soldier's rate}}{\text{captain's rate}}=\frac{1-x}{x}=\frac{x}{1+x}$.

Whence, $x^2=(1+x)\ (1-x)=1-x^2$, which gives $2x^2=1$.

Therefore $x=\frac{\sqrt{2}}{2}=0.707$ mile.

The whole distance traveled by the captain $=BC+2BC=1+2x=2.414$ miles. It is evident that the time required to march the mile is not necessary for the solution of this problem.

Also solved by W. E. Buker, Leetsdale, Pa., John Bellards, St. Nainz, Wis., Charles W. Trigg, Los Angeles, Calif., and Wallace H. Leebel, Roselle, N. J. and John W. Turkey, New Bedford, Mass.

1291. *Proposed by W. E. Buker, Leetsdale, Pa.*

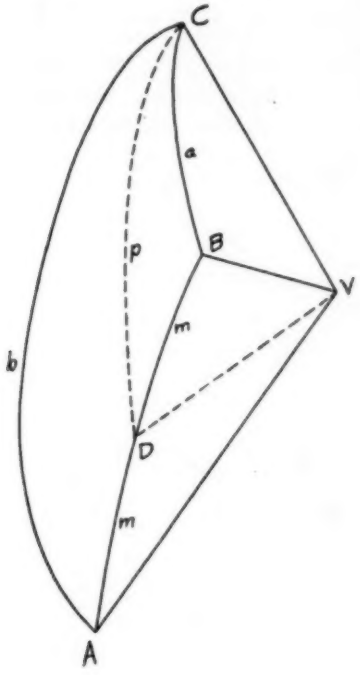
Prove or disprove: If two of the face angles of a trihedral angle are supplementary, the bisector of the remaining face angle is perpendicular to their common side.

Solved by Charles W. Trigg, Cumnock College, Los Angeles, Calif.

Given: Trihedral angle $V-ABC$ with face angles AVC and BVC supplementary, VD bisecting face angle AVB.

To prove: $VD \perp CV$.

PROOF: With V as center and any convenient radius describe a sphere cutting the faces of the Trihedral angle.



Then great circle arcs $AC = \angle AVC = b$, $BC = \angle BVC = a$, and $AB = \angle AVB = 2m$.

Since VD bisects $\angle AVB$, $AD = DB = m$.

Draw great circle arc $CD = p = \angle CVD$.

In spherical $\triangle ABC$,

(1) $\cos a = \cos b \cos 2m + \sin b \sin 2m \cos A$

In spherical $\triangle ACD$,

(2) $\cos p = \cos b \cos m + \sin b \sin m \cos A$

Eliminating $\cos A$ from (1) and (2),

$$\frac{\cos a - \cos b \cos 2m}{\sin b \sin 2m} = \frac{\cos p - \cos b \cos m}{\sin b \sin m}$$

Expressing the functions of $2m$ in terms of the functions of m, solving for $\cos p$, and simplifying,

$$\cos p = \frac{\cos a + \cos b\,(\sin^2 m + \cos^2 m)}{2 \cos m}$$

$$= \frac{\cos a + \cos b}{2 \cos m}$$

But, $a + b = 180°$, whence $\cos a + \cos b = 0$, $0 < m < 180°$, whence $\cos m \neq 0$.

$\therefore \cos p = 0.$
$\therefore p = 90° = \angle CVD$, and $VD \perp CV$.

1266. *Proposed by O. T. Snodgrass, Columbia, Missouri.*

Given a sphere of radius "a," and a square shaft, with a side of a cross section of the square, "b." Find the volume cut out by this shaft whose central axis passes through the center of the sphere

Solved by Charles Louthan, Columbus, Ohio

The reader is referred to another solution offered in the October issue.

By Rectangular coordinates: with $b = \frac{x}{2}$.

$$z = \sqrt{a^2 - x^2 - y^2}$$

$$\therefore V = 2.4 \int_0^b \int_0^b \sqrt{a^2 - x^2 - y^2}\, dy\, dx$$

$$= 4 \int_0^b \left[y\sqrt{(a^2 - x^2) - y^2} + (a^2 - x^2) \sin^{-1} \frac{y}{\sqrt{a^2 - x^2}} \right]_0^b dx,$$

which reduces to

$$2b\left[b\sqrt{a^2 - 2b^2} + (a^2 - b^2) \sin^{-1} \frac{b}{\sqrt{a^2 - b^2}} \right] + 4 \int_0^b (a^2 - x^2) \sin^{-1} \frac{b}{\sqrt{a^2 - x^2}}\, dx,$$

where the last integral is found by "Parts" to be,

$$F = (a^2 x - x^3) \sin^{-1} \frac{b}{\sqrt{a^2 - x^2}} + \frac{6}{3}\left[\frac{3a^2 + b^2}{2} \sin^{-1} \frac{x}{\sqrt{a^2 - b^2}} + \frac{x\sqrt{(a^2 - b^2) - x^2}}{2} \right.$$

$$\left. - 2a^2/b \tan^{-1} \frac{bx}{a\sqrt{(a^2 - b^2) - x^2}} \right]_0^b.$$

Substitution and further reduction gives

$$V = 8/3b\left[b\sqrt{a^2 - 2b^2} + (3a^2 - b^2) \sin^{-1} \frac{b}{\sqrt{a^2 - b^2}} - a^2/b \tan^{-1} \frac{b^2}{a\sqrt{a^2 - 2b^2}} \right].$$

For $a = 4$, $b = 2$, or $a/2$,

$$V = a^3/3\left[\sqrt{2} + 11 \sin^{-1} \frac{\sqrt{3}}{3} - 8 \tan^{-1} \frac{\sqrt{2}}{4} \right]$$

$$= 64/3\left[\sqrt{2} + 11 \sin^{-1} \frac{\sqrt{3}}{3} - 8 \tan^{-1} \frac{\sqrt{2}}{4} \right]$$

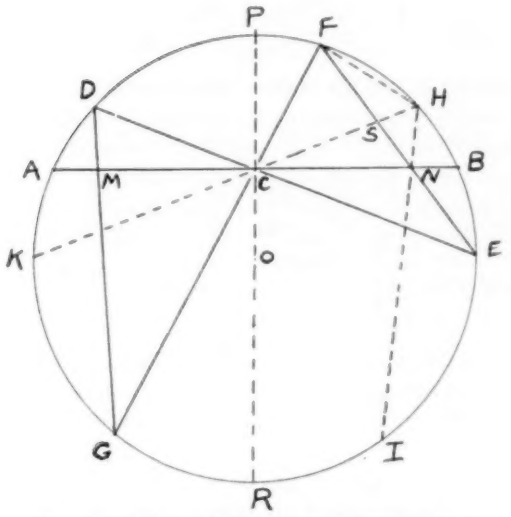
$$= 116.6 \text{ cu. units, as in (a).}$$

NOTE: Mr. Lonthan also offered a solution by cylindrical coordinates which also gave a volume of 116.6

1265. *Proposed by Nathan Nicholson, Philadelphia, Pa.*

Given a circle, O, with chord AB and C its midpoint. Through C draw any two chords DE and FG. Draw lines DG and FE intersecting chord AB at M and N respectively. Prove by methods of elementary geometry that $MC = NC$.

Draw diameter PCR; Lay off $\overset{\frown}{PH} = \overset{\frown}{PD}$
Draw HNI and HCK and FH



Solved by M. E. MacGregor, Boston, Mass.

$\angle SNC$ is measured by $\frac{1}{2}(\overset{\frown}{AF}+\overset{\frown}{BE})$

$\angle KHF$ is measured by $\frac{1}{2}(\overset{\frown}{AF}+\overset{\frown}{AK})$

$\overset{\frown}{DP}=\overset{\frown}{PH}$; $\overset{\frown}{AD}=\overset{\frown}{HB}$; $\angle ACD=\angle HCB=\angle ACK=\angle BCE$

$\overset{\frown}{AK}=\overset{\frown}{BE}$; $DC=CH$; $\therefore \angle SNC=\angle KHF$

$\angle FSH=\angle CSN$ $\therefore \triangle CSN$ similar $\triangle FSH$; $\therefore \dfrac{FS}{CS}=\dfrac{SH}{SN}$

$\angle HSN=\angle CSF$ $\therefore \triangle HSN$ similar $\triangle FSC$
$\therefore \angle HNS=\angle HCF$ & $\angle NHS=\angle SFC$

$\angle HNS$ measured by $\frac{1}{2}(\overset{\frown}{FH}+\overset{\frown}{IE})$

$\angle FCH$ measured by $\frac{1}{2}(\overset{\frown}{FH}+\overset{\frown}{KG})$

$\therefore \overset{\frown}{IE}=\overset{\frown}{KG}$

$\angle KHI$ measured by $\frac{1}{2}(\overset{\frown}{IG}+\overset{\frown}{KG})$; $\angle GDC$ measured by $\frac{1}{2}(\overset{\frown}{IG}+\overset{\frown}{IE})$
$\therefore \angle CHN=\angle MDC$; $\therefore \triangle MDC$ congruent to CHN; $\therefore CM=CN$.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1290. Barbara Kimbrough, Jerry Barker, and William Bayne, The Lewis and Clark H. S., Spokane, Washington.

PROBLEMS FOR SOLUTION

1304. Proposed by Howard D. Grossman, Brooklyn, N. Y.

Prove: $\sqrt{2}=\dfrac{1+1/3-1/5-1/7+1/9+1/11-1/13-1/15+\cdots}{1-1/3+1/5-1/7+1/9-1/11+1/13-1/15\cdots}$

1305. Proposed by D. Moody Bailey, Belsprings, Va.

A triangle and three cevians are given. Prove that the parallels to respective cevians through mid points of the sides are concurrent.

1306. Proposed by H. G. Ayre, Waukegan, Illinois.

P is a point outside of a circle O from which secants PBA and PCD are drawn. Q is another point outside of the circle such that QCB and QDA are secants. PU and QV are tangents to the circle. Also PM and QM are the bisectors of angles APD and AQB respectively. Prove that

$$\overline{PQ}^2=\overline{PU}^2+\overline{QV}^2=\overline{PM}^2+\overline{QM}^2$$

1307. Proposed by E. C. Kennedy, Austin, Texas.

If a rubber ball rebounds to one half of the height from which it has fallen, how long will it take it to come to a complete rest if the initial fall is 48 feet?

1308. Proposed by C. E. Sharp, Jr., St. Louis, Mo.

In a right-angled tetrahedron the square of the face opposite the right trihedral angle is equal to the sum of the squares of the three adjacent faces.

1309. Proposed by C. W. James, Eldon, Ohio.

Prove that the radius r of the circle inscribed in a right-angled triangle is less than one-half of either of the legs and also less than one-fourth of the hypotenuse.

SCIENCE QUESTIONS

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio

November, 1933

Readers are invited to co-operate by proposing questions for discussion or problems for solution.

Examination papers, tests, and interesting scientific happenings are very much desired. Please enclose material in an envelope and mail to Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

ALUMINUM EXPLODES!!

From front page write-up in the Cleveland Plain Dealer October 6, 1933.

630. Can and will aluminum "explode?"

Something exploded. If aluminum did not explode, what did?

The reporter said—"The explosion occurred when the three (injured men) poured water on smouldering aluminum shavings."

The fire chief said—"Water on the hot metal generated a gas."

What gas and did the gas come from the aluminum?

Segal (one of the injured workmen) said, "I climbed to the top of a pile of barrels and bags and started to sprinkle the pile of shavings from a hose. A sheet of flame blew me 50 feet."

What is the real truth about this explosion?
Can some one write an equation?

A STUDY UNIT ON METALLURGY

631. *From E. W. Bemisderfer, East Technical High School, Cleveland, Ohio. The following was found in use in a class at East Tech. What have you that other teachers would like to see?*

Probably the most interesting thing about metals is the method by which they are extracted from their ores. Heating energy is generally used but as electrical energy becomes cheaper it will also come into use. The ore is treated in somewhat the following manner:

The ore is usually found as an oxide, sulphide or carbonate. If it is found as an oxide the oxygen may be removed by reduction and the metal refined. On the other hand if it exists in the form of a carbonate a sulphide or any other salt, it is necessary to first convert that salt into an oxide. Study this procedure carefully as in the case of Lead and Copper. Metallurgy which is the EXTRACTION OF A METAL FROM ITS ORE, is carried out generally in three steps.

1. Roasting or oxidising
2. Reducing
3. Refining

Study carefully the reduction of iron ore in the blast furnace. Describe the blast furnace in detail and tell whether the process is continuous or is carried out in charges of so much ore and so much metal. You will observe that this ore is not roasted but reduced. (What is the reducing agent?) And then it is refined in the reverberatory furnace. (What is the product of this furnace called?) It is also mixed with other elements such as Nickel and Chromium in various percentages to form steel. Steel is an alloy. Is an alloy a mixture or a compound? Or may it be both? An open hearth furnace is used when the ore contains steel impurities. Why? What? List the various kinds of steel, including stainless steel and indicate the various elements found in each type. Indicate the particular property or properties of each type of steel. Is a Safety Razor blade steel? Is a watch spring steel? If you are manufacturing a shaft would an antifriction metal be desirable? What metal might be alloyed with the iron?

1. Which contains more iron and how much more? A ton of hematite or a ton of Magnetite?

2. What weight of lead would be required to prepare ten pounds of "Sugar of Lead?"

3. If you purchase 100 pounds of "Green Vitriol" what weight of copper Sulphate will you have?

4. What weight of green vitriol would be oxidised in the preparation of 100 grms. of Ferric Sulphate?

5. What weight of quicklime can be prepared from 100 tons of Limestone? 90% Calcium Carbonate.

6. In a steel bridge weighing 1000 tons, what weight of iron was used if the sample of steel showed 3% nickel, $\frac{1}{2}$% Chromium, and $\frac{3}{4}$% Carbon.

7. How many grams of Chromium can be made from 1630 grams of Chromic oxide by the thermite process?

8. What weight of coke, 97% Carbon, would be required to reduce 100 lbs. of "Cassiterite"?

9. Calculate the weight of aluminum in 100 lbs. of common alum?

10. In the reduction of one kilogram of cinnabar, what volume of Sulphur dioxide is formed?

11. Define metallurgy.

12. What is slag?
13. What is an ore?

FUNDAMENTAL THINKERS FORWARD!!

Logic is a science and some science is logic. Ripley, in "Believe it or Not," recently used something like the following—

632. A quart is $\frac{1}{4}$ of a gallon; a quart is $\frac{1}{8}$ of a peck; and a gallon is not $\frac{1}{2}$ of a peck. Why?

ANALOGY TESTS

Submitted by William Malkin, Cloverton Consolidated School, Cloverton, Minn.

633. **Analogy** **Plants**

Complete the following:
Example: light : day :: dark : _____.

To be read as follows: "Light is related to day as dark is related to _____. Answer is night.

Therefore: light : day :: dark : night.

1	bean	: dicotyledon	:: corn	: .....
2	garden	: toads	:: tree	: .....
3	embryo	: seed	:: nucleus	: .....
4	animals	: nostrils	:: plants	: .....
5	mature ovule	: seed	:: ripened ovary	: .....
6	less vigor	: self-pollinated	:: greater vigor	: .....
7	minerals	: inorganic	:: humus	: .....
8	pollen lodging on stigma	: pollination	:: union of nuclei	: .....
9	radish	: annual	:: oak	: .....
10	buds	: used in budding	:: branches	: .....
11	like varieties	: self-pollination	:: new varieties	: .....
12	airplane	: landing field	:: pollen grain	: .....
13	sieve	: openings	:: leaf	: .....
14	iodine	: starch	:: Fehling's solution	: .....
15	contain pigment	: algae	: lack green pigment	: .....
16	tree	: trunk	:: stamen	: .....
17	plant	: stem	:: pistil	: .....
18	water	: hydrotropism	:: light	: .....
19	gravity	: geotropism	:: moisture	: .....
20	showy flowers	: insect pollinated	:: inconspicuous flowers	: .....
21	prison	: iron bars	:: stomata	: .....
22	oxidation	: carbon dioxide	:: photosynthesis	: .....
23	age of a horse	: teeth	:: age of a tree	: .....
24	conducts water	: xylem	:: conducts food	: .....
25	boll weevil	: cotton plant	:: codling moth	: .....
26	Mothers	: Mother's Day	:: trees	: .....
27	birds	: check insects	:: forests	: .....
28	soldier	: helmit	:: root hair	: .....
29	anther	: contains pollen grains	:: ovary	: .....
30	accessory parts	: petals and sepals	:: essential parts	: .....

31	yellow fever parasite	: mosquito and man	:: red rust	:	....
32	bread mold	: reproduce by spores	:: yeasts	:	.. ..
33	leguminous crops	: nitrogen	:: dry farming	:	....
34	foundation	: building	:: receptacle	:	....
35	insects	: chitin	:: plant cells	:	.....
36	irregular cells	: spongy mesophyll	:: columnar cells	:	.....
37	leaves	: stomata	:: stems	:	....
38	fungi	: mycelium	:: seed plants	:	.....
39	testa	: furnishes protection	:: endosperm	:	.....
40	guard cells	: in lower epidermis	:: air spaces		.....
41	loose leaves periodically	: deciduous	retain leaves		..... .
42	bark	: protects stem	:: cutin	:	.....
43	interrelated on earth	: plants and animals	:: symbiotic in lichens	:	.....
44	one party at a disadvantage	: parasitism	:: mutual advantage	:	.....
45	windows	: air and sunshine	:: micropyle	:	.....
46	insects	: metamorphosis	:: ferns	:	.....
47	sprouted pollen grain	: gametophyte	:: pollen producing plant	:	.....
48	frogs	: hibernate	:: bacteria	:	.....
49	sieve vessel	: phloem	:: spiral vessel	:	.....
50	edible	: mushroom	:: poisonous		

Do you, Readers, wish to have the answers published?

QUESTION RAISERS AND ANSWERERS

All readers of SCIENCE QUESTIONS must know how difficult it is to have questions and answers that are really interesting to readers—teachers and students alike. Also, think of teachers and investigators in foreign lands who read SCHOOL SCIENCE AND MATHEMATICS and depend upon it for new ideas and ideas reflecting educational practice in the United States of America.

634. *What would you think of a "Guild of Question Raisers and Answerers?"*

(We might organize as a union under the N.R.A. if we should show marked signs of working overtime.)

Suppose the EDITOR starts a roll of charter members beginning with those who contribute this school year (October, 1933 to June, 1934).

The first name on the list would be

1. John C. Packard, Brookline, Mass.

We might appoint him "Dean of the Guild."

Then,

2. Walter E. Hauswald, Beardstown, Ill.
3. Walter C. Pribnow, Sparta, Wisconsin.
4. William W. Johnson, Cleveland, Ohio.
5. A. G. Zander, Milwaukee, Wisconsin.
6. E. W. Bemisderfer, Cleveland, Ohio.
7. William Malkin, Cloverton, Minnesota.

Your name will be added as soon as your name appears as a contributor. Please help out with new or tried ideas—questions, tests, etc.

Send in your tests and questions!!

BOOKS RECEIVED

The Living World, by Helen Gardner Mank, Head of the Department of Biology, High School, Lawrence, Massachusetts. Cloth. Pages xxiv+673. 13.5 x 19 cm. 1933. Benj. H. Sanborn and Co., 221 East 20th Street, Chicago, Illinois. Price $1.68.

A Textbook of Physics, Vol. III, Electricity and Magnetism, by E. Grimsehl. Edited by R. Tomaschek, Professor of Physics, the University of Marburg. Authorized Translation from the Seventh German Edition by L. A. Woodward. Cloth. Pages xiv+685. 806 figures. 14.5 x 22 cm. Blackie and Son, Limited, 50 Old Bailey, London, E.G.4. Price 25s. net.

Trees of North America, Vol. I, The Conifers, by George Rex Green, Professor of Nature Education and Director of the Nature Camps, Pennsylvania State College, State College, Pennsylvania. Paper. Pages iv+186. 20 x 27.5 cm. 1933. Edwards Brothers, Ann Arbor, Michigan. Price $2.00.

Sex in the Plant World, by Wilfred W. Robbins, Professor of Botany in the College of Agriculture of the University of California and Helen Monosmith Pearson, Research Assistant in Viticulture in the College of Agriculture of the University of California. Cloth. Pages xii+193. 12.5 x 19 cm. 1933. D. Appleton-Century, Inc., 35 West 32nd Street, New York, N. Y. Price $2.00.

Einführung in die Physikalische Chemie, von Studienrat Dr. Emil Fischer. Cloth. 120 pages. 11.5 x 18.5 cm. 1933. B. G. Teubner, Leipzig. Price R.M. 3.00.

Kegelschnittlehre, von Dr. W. Lietzmann, Oberstudiendirektor der Oberrealschule mit Reform-Realgymnasium in Göttingen. Paper. 46 pages. 36 figures. 11.5 x 18.5 cm. B. G. Teubner, Leipzig. Price R.M. 1.20.

PAMPHLETS RECEIVED

An Experiment in the Use of a Teaching Unit in Science, by Archer Willis Hurd, Institute of School Experimentation, Teachers College, Columbia University. Pages vi+50. 14.5 x 23.5 cm. 1933. It may be obtained by addressing A. W. Hurd, Institute of School Experimentation, 433 West 123rd Street, New York and, enclosing 60 cents plus 3 cents postage.

Analysis of Special Jobs in Farm Forestry. Bulletin No. 169. Agricultural Series No. 44. Pages vii+45. 15 x 23 cm. June 1933. Superintendent of Documents, Government Printing Office Washington, D. C. Price 10 cents.

Illinois Mineral Industry in 1932, by W. H. Voskuil and Alma R. Sweeny. 66 pages. 17 x 25.5 cm. State Geological Survey Division, Urbana, Illinois.

The Eye and How We See, A Manual for Teachers. 19 pages. 17.5 x 25.5 cm. 1932. Better Vision Institute, 205 East 42nd Street, New York, N. Y.

BOOK REVIEWS

Descriptive Geometry, an Introduction to Engineering Graphics, by F. H. Cherry, Associate Professor of Mechanical Engineering, University of California. Pages xi+127. 15 x 22 cm. Cloth. Macmillan. New York. 1933. Price $2.00.

The aim of the author is to present descriptive geometry in a form which will appeal to the engineering student. To accomplish this purpose he has selected a group of propositions which he believes to be of fundamental and practical importance from the standpoint of engineering. In order to make the subject interesting to an engineering student he has

chosen many concrete problems to which the student may apply the abstract theory. These problems have been so chosen that the student may not encounter too much difficulty in their solution.

The revolution" and "auxilliary plane" methods have both been used. The choice of the method depends upon the type of the problem to be solved. There are 21 propositions, 50 examples, and 93 problems. This material is enough to keep the average student busy for one semester.

J. M. KINNEY

Tours Through the World of Science, by William T. Skilling, State Teachers College, San Diego, California. First Edition. Cloth. Pages xiv+758 12.5 x 19 cm. 1933. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. $1.70.

This textbook in general science presents in a new and refreshing way nineteen tours through the world of science. Each tour (unit) is begun with a brief statement telling where the path will lead. This is followed by suggestions in making preparations for the tour. The subject matter within each tour is well organized and written with a vocabulary and sentence structure well adapted to pupils of the junior high school grades. The numerous paragraph headings, in boldfaced type, form a complete analysis of each tour. The diagrams and pictures are well adapted for teaching purposes. They are not mere space fillers. Experiments and demonstrations are placed in the sections to which they relate and include many thought questions.

At the conclusion of each tour pupils are asked to tell about the interesting things they have seen. Questions are given to test understanding. The suggested home projects will encourage pupils to solve some problems closely related to these tours. If the suggestions in the textbooks are followed pupils will discover they are using a unique way in studying, reviewing and outlining the material in each tour.

The author overstates the facts in some situations in order to popularize the subject matter or to make certain topics or principles appear interesting. Two statements on one page will illustrate. One statement is made in connection with the energy furnished by running water: "We shall find that this energy was given it by the sun when the sun reached down with its rays and lifted the water up from the sea." Another statement: "One more look we must take before ending our tour. This time we shall see water working in its own natural way, cutting the mile-deep canyon of the Colorado and a million lesser channels."

I. C. D.

Work-study Book for Beginning Chemistry, by F. C. Coulson, Instructor of Chemistry, Crane High School, Chicago, Ill. Paper. 20.2 x 27.1 cm. 288 pages. Price 80 cents. Published by the author.

For the teacher who considers a work book a desirable adjunct to his course this work-study book merits consideration. The author has compiled a comprehensive and well rounded mass of drill work devised with the idea of being used in the classroom under supervision or outside the classroom, as an adaptable study tool for the pupil. For the experienced teacher whose course is made distinctive through his own personal touch the book will prove suggestive.

The book is divided into nine units—(1) Matter, Its Composition and Changes; (2) Oxygen, Hydrogen, Gas Laws; (3) Water, Hydrogen Peroxide, Colloids; (4) Atomic and Molecular Weights, Equations, Chemical Arithmetic; (5) Acids, Bases and Salts; (6) The Structure of Matter; (7)

Non-metallic Elements, Periodic Classification; (8) Organic Chemistry; (9) Metallic Elements, and their Compounds. A valuable part of the book is the appendix, consisting of two parts, one the traditional tables common to all books of this type, and the other instructions for formula construction, for writing equations, for solving problems and for balancing oxidation and reduction equations. A comprehensive list of reference books to aid in the students' tasks also appears in the appendix.

Each unit is built up of a vocabulary, a wide and comprehensive mass of completion tests, tables for the students to complete, and honor work, consisting of suggested subjects for oral or written reports.

Every book should be individual in at least one respect from the mass of books of this type now appearing, or there is no reason for its existence. This book answers that requirement in that the author has introduced that bugbear to many students—formula writing, equations and chemical arithmetic—in a novel manner at the beginning of the course and then carries it through logically to the end with a distinctly individual touch.

Recommended, especially for the beginning teacher and the bright pupil.

W. McCRORY

A Textbook on Heat, by A. W. Barton, Assistant Master at Repton School, Cambridge, England. Cloth. Pages xiii+378. 13 x 19.1 cm. 1933. Longmans, Green and Company, 55 Fifth Avenue, New York. Price $2.75.

This is a text of Junior College grade. It is well organized and is written in a clear and logical style. The brighter students of physics in high school can read it with profit. In general this text shows "that the study of natural knowledge is as truly cultural as that of literature or art."

The subject is divided into fifteen chapters, each of which ends with a set of well selected questions and problems; many of these were taken from English entrance and matriculation examinations. Illustrations are used primarily for their instruction value. Some of the topics which are treated exceptionally well are:

Errors of the Mercury Thermometer
Evaporation
The Electrolux Refrigerator
The Hair Hygrometer
The Kinetic Theory of Matter
The Liquefaction of Gases
The Properties of Radiation
The Measurement of the Temperature of the Sun

Answers to problems are given at the end of the book.

For the high school teacher of physics or of general science this book should provide a good review of subject matter; it will help him especially to present the fundamental concepts of the subject in a lucid and thorough manner. Recommended for the professional library.

W. F. ROECKER

A Laboratory Manual to Accompany Principles of General Chemistry, by Erwin B. Kelsey and Harold G. Dietrich, Assistant Professors in Chemistry, Yale University. Revised Edition. pp. x+133+73. 2.7 x 15 x 23 cm. Illustrated with a number of figures of apparatus. Cloth. 1933. Macmillan.

This is a substantial, well bound book, in similar dress to Brinkley's text, "Principles of Chemistry," which it was written to accompany. One side of each page is usually left blank for the taking of notes, the authors being very much opposed to the taking of notes on "loose pieces of paper,"

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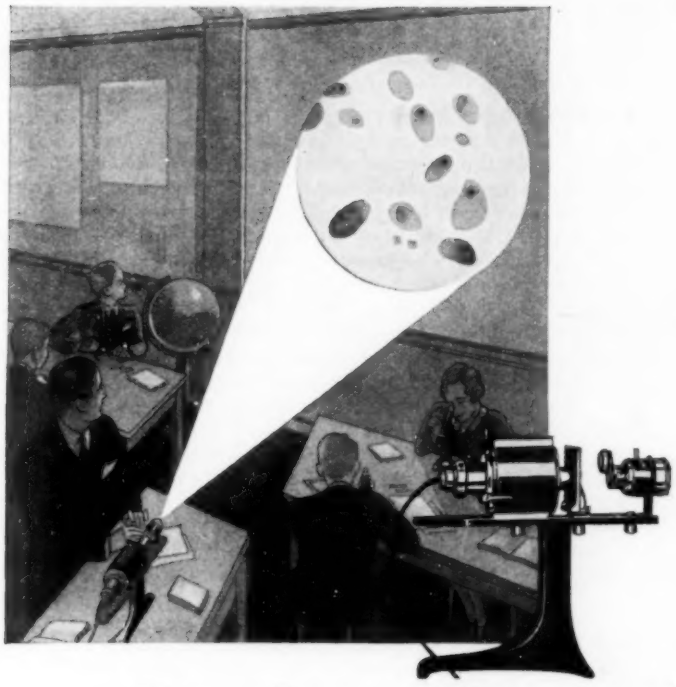

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a most unbusinesslike procedure at best. Section I of the manual deals with inorganic chemistry and Section II with Elementary Qualitative Analysis. Since the majority of college students have had some laboratory experience in high school chemistry some of the simple preparations, such as the preparation of oxygen and hydrogen are omitted and several inorganic preparations requiring the use of substantial amounts of material and the application of certain chemical principles are substituted for them. This work is roughly quantitative with calculation of yield. A careful reading of several of the experiments, notably the determination of the molecular weight of carbon dioxide and the atomic weight of tin shows well planned clearly worded directions. The work toward the latter part of the Inorganic section begins to lead toward qualitative analysis with a study of equlibrium in solution, solubility product and conditions leading toward precipitation. The Qualitative section does not pretend to be a complete system of qualitative analysis but rather a series of experiments leading to a study of the principles used in the separations of qualitative analysis. College teachers will want to see this revision and high school teachers will find it a valuable addition to their departmental libraries. It will afford many an experiment for the student who is ahead of the rest of the class to work out and perhaps present to the class

FRANK B. WADE

Plane Trigonometry, by John A. Northcott, Associate Professor of Mathematics, Columbia University. Pages ix+149. 14 x 20.5 cm. Cloth. Ray Long and Richard R. Smith, Inc., New York. 1933.

The author of this book believes that the central theme of trigonometry should be analysis; that computation should be subordinate. Accordingly he devotes two chapters out of nine—the second on the solution of the right triangle and the ninth on the solution of triangles—to computation.

The functions are defined in the general form. The attention of the student is directed to the fact that the results of computation can be no more accurate than the data. The text is brief. There are 500 problems.

J. M. KINNEY

Life's Place in the Cosmos, by Hiram Percy Maxim. Cloth. Pages xi+176. 14 x 21 cm. 1933. D. Appleton and Company, 35 West 32nd Street, New York, N. Y. Price $2.50.

Hiram P. Maxim is a well known inventor and electrical engineer. He is at present president of the Maxim Silencer Company, manufacturers of his famous silencer for fire-arms. He has in brief, tried to impress upon the reader the insignificance of man in the great universe in which he lives. The first chapter deals with our own solar system and its relation to us. The next pictures our galaxy. The following chapters present descriptions of other galaxies, life and its possibilities, evolution, intelligence, and last, his conclusions, which involve a discussion of the problems which confront us in the study of such topics.

He does not attempt to formulate any new theories but merely collects many of the older ideas, compares them and draws his own conclusions. His illustrations are amusing as well as accurate. The language is easily read by one not versed in astronomy. The book contains several of the most remarkable photographs of stellar bodies ever taken. Without a doubt even the most learned scientist as well as the less informed reader will enjoy pondering over its contents.

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RALPH D. BEETLE, *Consulting Editor*

PLANE TRIGONOMETRY

By C. A. EWING

Head of the Department of Mathematics, The Tome School, Port Deposit, Md. 162 pages, 5½x8, illustrated. $1.20. With 5-Place Tables, $1.60. Answers are available to teachers.

THIS new text presents the subject in the order of its historical development to secure the pupil's interest at the start and appeal to his desire to learn things which have a practical application. Part I takes up the solution of triangles and their various applications. Part II deals with the functions of the general angle and their relations. The treatment of computation is unusually complete. The theory of logarithms is developed in addition to the usual treatment of logarithms in relation to computation. The more common uses of the slide rule are explained.

• • • •

"This is not just another textbook, but is one which has recognized some of the psychologic factors involved in learning. . . . It should find its way into every secondary school because it has tremendous possibilities."—Dr. W. J. Klopp, Supervisor of Secondary Education, Long Beach, California.

"A very usable book containing all the topics ordinarily taught in a high school course in Trigonometry, with adequate and interesting exercise material. The tables are clear, easily handled, and not tiring to the eyes."—Alice W. Farrar, Brockton, Massachusetts, High School.

Some Recent Adoptions

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Mt. Hermon School, Mt. Hermon, Mass.
North Union Twp. School, Noremberg, Pa.
Shady Side Academy, Pittsburgh, Pa.
Tome School, Port Deposit, Md.
University School, Cleveland, Ohio
William Penn Charter School, Philadelphia, Pa.
Gettysburg School, Gettysburg, Pa.
Morristown School, Morristown, N.J.
St. Mark's School, Southborough, Mass.

PLANE GEOMETRY

By RAY D. FARNSWORTH, Head of the Department of Mathematics, Chauncy Hall School, Boston, Mass. 258 pages, 5½x8. $1.25

EXAMPLES IN PLANE TRIGONOMETRY

By WINFIELD M. SIDES, Department of Mathematics, Phillips Academy, Andover, Mass. 79 pages, 5x8. $0.70

McGRAW-HILL FIVE-PLACE LOGARITHMIC AND TRIGONOMETRIC TABLES

Edited by RALPH D. BEETLE, Professor of Mathematics, Dartmouth College. 131 pages, 5½x8. $0.80

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BOOKS FOR ELEMENTARY PUPILS

Pathways in Science, Book I, We Look About Us by Gerald S. Craig, Assistant Professor of Natural Sciences, Teachers College, Columbia University and Agnes Burke, Teacher in Horace Mann School and Instructor in Kindergarten—First Grade Education, Teachers College, Columbia University. Cloth. Pages v+194. 13 x 19 cm. 1933. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price 68 cents.

A science reader for the youngest elementary pupils; answers their childish questions about the things in nature, shows them new things, provides interesting activities, stimulates thought, and developes correct attitudes; artistic and attractive.

My First Drill Book in Numbers, by C. L. Thiele, Director of Exact Sciences, Detroit Public Schools and Irene Sauble, Supervisor of Exact Sciences, Detroit Public Schools. Paper. 103 pages. 17 x 23 cm. 1932. Rand McNally and Company, 538 S. Clark Street, Chicago, Illinois.

An attractive number exercise and drill book for beginners; illustrated in colors, with story problems, games, and tests.

Surprises, Book Three of Nature and Science Readers by Edith M. Patch and Harrison E. Howe. Cloth. Pages xiii+307. 13.5 x 18.5 cm. 1933. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 84 cents.

This book is appropriately named. Intersting nature study facts about foods, textiles, animals, fuels, weather, rocks, and the sky; instructive science games included; attractively bound and illustrated.

Through Four Seasons, Book Four of Nature and Science Readers by Edith M. Patch and Harrison E. Howe. Cloth. Pages xiv+331. 13.5 x 18.5 cm. 1933. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 88 cents.

A worthy sequel to "Surprises," but it is far more than the name suggests for it tells not only of spring rains and summer sun but about seasonal occupations and products, animal and bird habits under changing environment, tides, dunes, fertilizers, soil, etc.—an excellent science reader for the older elementary pupils.

ARCHEOLOGIST FINDS PREHISTORIC MOUND USED AS PARK KITCHEN

Invited to inspect a new municipal park at Newark, Dr. H. C. Shetrone of the Ohio State Museum has discovered that the scenic point chosen for a fine outdoor kitchen is a prehistoric Indian mound.

The mound is cone-shaped and stands on the summit of a high hill. Dr. Shetrone states that, without opening it, no one can tell whether it was built as an Indian burial place or as the setting for Indian ceremonies. The mound will be opened with a few days to determine its ancient use, and to find out whether it contains objects of prehistoric interest.

Hundreds of picnic parties have prepared their lunches and roasted "hot dogs" at the fire place on the mound this summer without any idea that the high place was artificially raised many centuries ago.

Two areas in Newark that contain Indian mounds and earthworks were recently preserved by making them into state parks. One of these parks, containing a mound shaped like a spread eagle, was the scene of picturesque ceremonies earlier this month when citizens gathered by the prehistoric eagle to pledge support to the modern Blue Eagle of the N.R.A.
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FINDS BRONCHO-SINUSITIS MORE TO BE FEARED THAN TUBERCULOSIS

An ailment called broncho-sinusitis is more to be feared at present than tuberculosis, according to Dr. W. Walter Wasson of Denver, vice president of the American College of Radiology, who discussed this ailment at the American Congress of Radiology this morning.

"Broncho-sinusitis, a respiratory disease of the 'sinus trouble' and bronchitis type, while it does not produce the same mortality that tuberculosis does, is often very crippling to the child and adult alike," said Dr. Wasson. "This ailment begins very early in life, is insidious in its progress, and lays the foundation for a variety of symptoms which may become asthma, bronchitis, and sinus infection.

"Studies conducted by myself and associates in our Denver clinic have followed the child from birth to ten years of age, so that we have quite complete X-ray films of the sinuses and chest every three months from birth to ten years. This is a group of about 100 children, and is large enough to give us much information, as it reveals the life cycle of disease of an average group of American youngsters. Our information is thus available for teaching purposes."

Dr. Wasson emphasized the need for periodic examinations to watch for incipient broncho-sinusitis.—*Science Service.*

REGULATION OF RADIOLOGY AS MEDICAL SPECIALTY URGED

A code, professional rather than economic, is being urged for radiology, that branch of medicine which uses X-rays and radium for treating disease.

At the opening session of the American Congress of Radiology, the president of that body, Dr. Henry K. Pancoast of Philadelphia, said that radiology should be recognized as strictly a medical practice limited to physicians, and that a qualification board should be appointed to pass on the approval of radiologists as specialists. This is in line with action being taken by other special branches of medicine. In addition, he believes medical students and internes should be taught the true meaning and scope of scientific medical radiology.

"A large portion of the medical profession is still quite ignorant of the scope of X-ray diagnosis and irradiation treatment, of the principles on which both are based and of the essentials for proper training of a fully informed physician specialist in radiology," he declared. "Some slight encouragement may be found in the fact that in many localities similar attitudes are prevalent in respect to all specialties, in medicine and other professions."—*Science Service.*

PROPOSED AMENDMENT TO THE BY-LAWS OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

AMENDMENT XII.—Article 4, Section 2, shall be amended to read as follows:

"*Section 2. Number:* There shall be fifteen (15) members of the Board of Directors. The President, the Vice-President, and the President of the preceding year shall be ex-officio members of the Board of Directors. The remaining members of the Board of Directors shall be divided into three groups of four (4) directors each. The first Board of Directors shall be so chosen that members of the first group shall serve three years; members of the second group, two years; and members of the third group, one year. Thereafter four directors shall be elected annually to succeed those of the group whose terms are about to expire."

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